Improvement of human performance in safety: understand to act.

SUSTAINABLE DEVELOPMENT GOALS

8 DECENT WORK AND ECONOMIC GROWTH

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D.C. SAFETY EXCELLENCE PROGRAM

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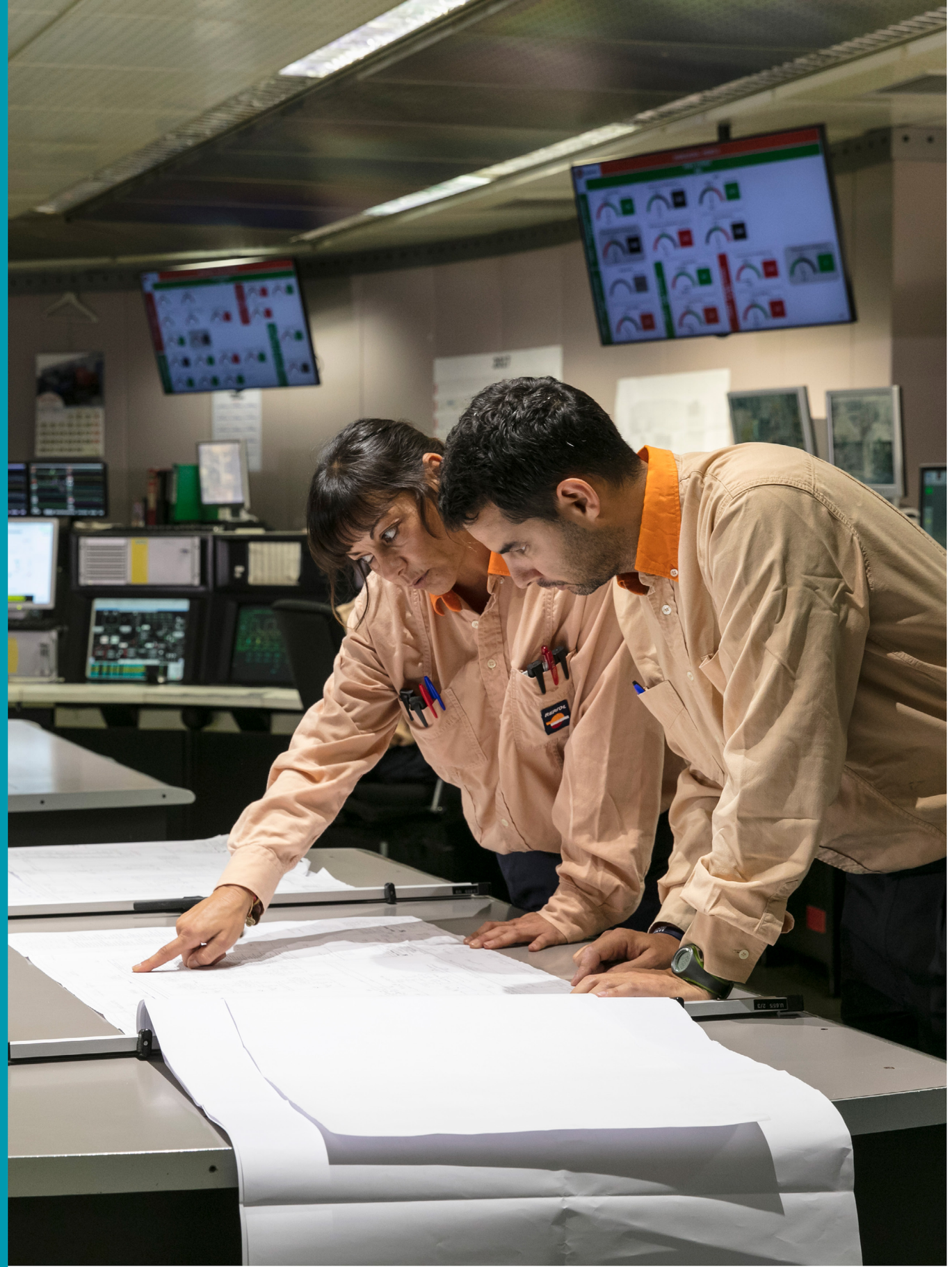
01

About this guide

In high-risk industries **human performance** is critical to ensure safety and reliability.

As companies, we can manage safety better by understanding the interrelationships between people and the rest of the organization.



Introduction

This guide's objectives

This guide will interest you if you are...

System thinking

"A framework for seeing interrelationships rather than things, for seeing patterns of change rather than static snapshots. Today, system thinking is needed more than necessary than ever because we are becoming overwhelmed by complexity."

Peter Senge
The fifth discipline

Introduction

Systems and work processes cannot cover all the possible variability and **it is us, the people, who make our work safer through our daily actions**. But we are not infallible and sometimes we make mistakes.

Our ability to respond to variability.

We face ever greater challenges and emerging market demands, as well as a multitude of changes (technological, organizational and environmental) that change our relationship with the environment, with work teams and with production facilities.

These challenges, new needs and uncertainties require organizations **to adapt constantly**, **be resilient** and maintain a **proactive attitude**, in order to continue operating safely.

In recent years, a great deal of industrial safety literature has been created focusing on "human factors." Although many sources share the same objectives, redundancies have been generated and some confusion created by the terminology used.

Some studies of human factors focus exclusively on human reliability or people as individuals, ignoring the influence that the system has on them. The system includes the organization, job position, environment and many more interrelationships with other people and work teams.

This guide clarifies the basic concepts related to "human factors," explains the influence of the system on human performance and the need to manage human factors proactively at all levels of organizations, and it proposes how we can adopt the best practices affecting our human safety performance, so we can continue to improve.

This guide's objectives

1
Understand the concepts
Understand all the system factors that influence our human performance in safety, taking account of them throughout our value chain.

2
Know the industry approach
Share the **industry's unique integrated vision** of managing human factors.

3
Manage factors
Learn **how to manage and integrate these factors**, which influence our human performance in safety. The goal is to create safe, leader-driven environments that promote reporting and foster a culture of safety.

4
Identify areas of action
Identify the **critical areas**, **tools and key processes** (design, risk analysis, tasks and emergency response) that help us improve and reinforce our learning about normal operations and performance in safety.

This guide will interest you if you are...

Manager or supervisor, with or without people reporting to them
Because complementing your technical knowledge with an understanding of human factors and people management skills will provide you with useful tools for promoting a culture of safety that incorporates key safety aspects in your team and in your work environment.

Engineer, analyst, consultant or expert
Because you will understand how your process design, planning, procedures, tasks, job positions and work teams will increase or reduce the probability of human error and, therefore, the occurrence of an incident.

Operational staff or anyone with an interest in this topic
Because acquiring a greater knowledge of human factors will help you improve your own safety performance in your job position, whether operational or managerial.

02

Key human performance concepts

It is useful to clarify the key concepts in order to understand how the interrelationships of people and the system influence human safety performance.

This will enable us to advance and continue to improve in the performance of any task with greater safety.

The importance of human performance

Key concepts

People, design and technology

Work-as-imagined versus work-as-done

Steps to analyze errors

Generate knowledge and skills

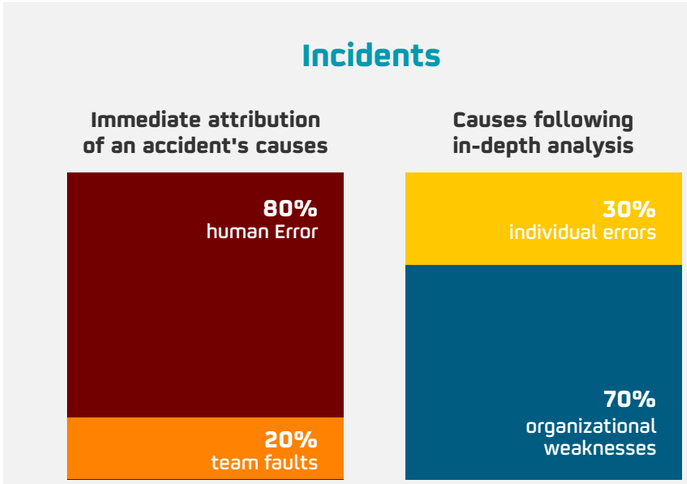
The importance of human performance in preventing incidents

Act proactively and identify the human factors that have affected performance.

We do not have to wait for an incident to occur before we act. We must act proactively and early to identify precursors of errors and act on their causes.

Near misses, if analyzed in depth, provide an excellent opportunity to define hazards and the causes and circumstances in which have occurred, and to correct management failures and the presence of a wide range of factors, such as fatigue, time or production pressure, distractions or poor design.

Although incidents are usually attributed to human error, when analyzed in depth, there is always a reason why the decisions or actions were taken. **Errors are the result of how we manage the human factors that influence performance**.



Active listening

Most error-prone situations can be detected, managed, and prevented. **It is important to listen actively to work teams, especially those closest to the operation**, to learn from normal work and have a proactive attitude to problems, changing processes and systems to make them safer. We must promote an environment in which people feel comfortable to speak, **acting on the different areas for progress** that we will suggest depending the scope that applies to you.

See areas for progress

The **10 most frequent human factors** compiled by Step Change from occupational health and safety inspections carried out by the UK government's HSE *(Health & Safety Executive)* on facilities subject to serious accidents are:

1. Organizational change and transition management
2. Demanning and Staffing levels
3. Training, competence and supervision
4. Fatigue from shiftwork and overtime
5. Alarms handing
6. Compliance with safety procedures
7. Safety culture/blame culture
8. Communications. For example, shift handover
9. Ergonomics
10. Maintenance errors

Organizational changes

This ranking shows how the corporate initiatives, organizational changes and management actions necessary for progress affect safety culture, which, in turn, affects people and their performance. Thus we can see that changes must be managed appropriately so that the safety culture always comes out strengthened.

As **a changing environment is unavoidable**, the entire organization must be prepared to face the dynamics of this environment, the different contexts and external and internal influences, and, based on all this, **make the necessary changes to promote better safety performance**. We must also always keep in mind that **people are part of the solution, not part of the problem, in safety matters**. Therefore, we must start by identifying the most operational aspects that can affect performance, as well as any system factors that could be involved in improving them.

Ethics and safety for a sustainable business

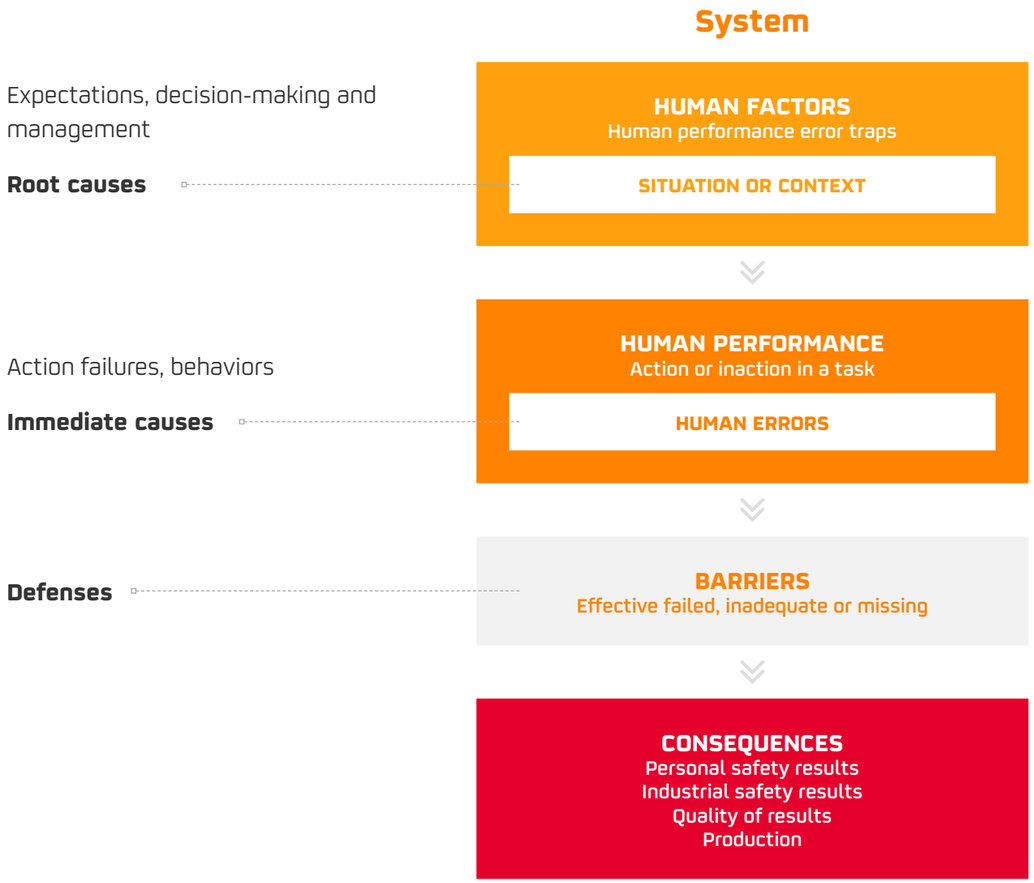
The visible commitment of leaders and all the people who make up the organization is necessary to improve the system's operation and, consequently, human performance in safety.

In order to improve safety, it is essential to have exemplary ethical behavior, to act with integrity, establishing the bases for a sustainable, safe, efficient business.

Key concepts

Sociotechnical system

Organizations are made up of a **complex system of interrelationships** between people, machines, equipment, technology, physical environment, activities, structures, processes and organizational conditions, which is called the "sociotechnical system." **Individuals contribute to this system with their actions**. **In turn**, **all aspects of the system reciprocally influence its performance and decision-making**. There are occasions when these interrelationships between technological, social and organizational aspects influence the real work environment or situation and become the precursors of accidents in safety. Most errors are predictable, in as much as the systems have weaknesses.



Human factors

A set of **physical, psychological, social and organizational conditions** that affect people and how they interact with different parts of the system, **thus determining the way in which people carry out their work**.

To achieve an improvement in safety, it is vital to integrate these human factors into management of the design of teams, jobs positions and work activities, and into safety risk management and training, to make it easier for people to carry out their work in the safest and most effective way.

Similar terms: human factor, ergonomics, performance incluencing factors, performance shaping factors, error producing conditions, error traps, flag conditions, preconditions, constraints.

Human performance

What people do and how they do it **in the context of their daily activities** at work. It is of key importance to identify their **critical tasks** (individual and team).

A **human Error** is defined as the occurrence of an unexpected action or failure that does not generate the expected result and that leads to, or could lead to, undesired consequences.

Human factors and human performance are two sides of the same coin.

Psychological safety

A team climate characterized by interpersonal trust and mutual respect in which people are comfortable being themselves. The belief that you will not be punished, humiliated or harmed for speaking up, questioning, sharing concerns or admitting mistakes.

Just culture

A culture in which the organization promotes the necessary psychological safety for information that can affect safety to flow transparently, in such a way that it makes it possible to anticipate, detect and correct unsafe conditions and latent risks in the system and learn from them. Just culture is based on two principles: that we all make mistakes and that we are responsible for our actions.

People, design and technology

People-centered design

This approach helps us to guarantee that services and products that we implement (systems, equipment or procedures) are **optimal and usable for end users**, allowing them to perform tasks safely and ensuring that the human factors that may affect their performance have been considered.

The **participation of users in the task design and planning process** is essential to understanding their needs and capabilities and thus facilitates their acceptance in implementation.

Minimize error in the life cycle of operations

Facilities and activities must be designed, updated and improved to reduce errors and manage risks throughout their life cycle in the best possible way.

During the operation, better knowledge is acquired of the facility and of existing conditions that can lead to errors. Over time, new technologies that improve safety are created, which may require modifications. Whatever the case, always keep users in mind when redesigning tasks.

"Successful efforts going forwards will be those that wrap new machine intelligence capabilities around human competencies in order to get the best out of each"

Dr. Alonso Vera
Chief of the Human Systems Integration Division at NASA Ames Research Center

Technology challenges

The introduction of **highly automated systems** poses a series of challenges related to human performance. Consequently, it is necessary to address and optimize the role of people in these systems.

Complex environment and objectives

People assess risks and adapt to the demands of a complex, dynamic work environment.

To do our work, we must constantly prioritize and make decisions, depending on the environment and in relation to different objectives, which often can be **contradictory**.

The system, the technology and the organizational culture influence our behavior. So, **social interactions, collaboration and communication between stakeholders are critical** to improve the system and safety.

Work-as-imagined *versus* work-as-done

Work plans help us anticipate operational needs and ensure that we have the right capacity to perform the corresponding tasks. Because while we are working we have to deal with **changing situations** and conditions that prevent us from performing tasks in an ideal way.

Work-as-imagined

The work that should be done in the foreseen circumstances. It determines how a process is established, how people are trained, and what controls need to be put in place. It is the idealized view of a formal task without taking account of the variations of changing work conditions and the environment for performance of the task.

Work-as-done

The work carried out, taking into account the real situation in which it is performed and that it depends on the equipment, procedures, time and resources available at that particular moment.

PRACTICAL CASE

Entering confined spaces

Work-as-imagined

A **work permit** is required for entry to a confined space, according to the **operational safety regulations**. The **confined space entry procedure**, which regulates the safety conditions for access, **requires workers to understand**, before starting the work, **the hazards and the associated tasks** for compliance with the authorized measures.

Work-as-done

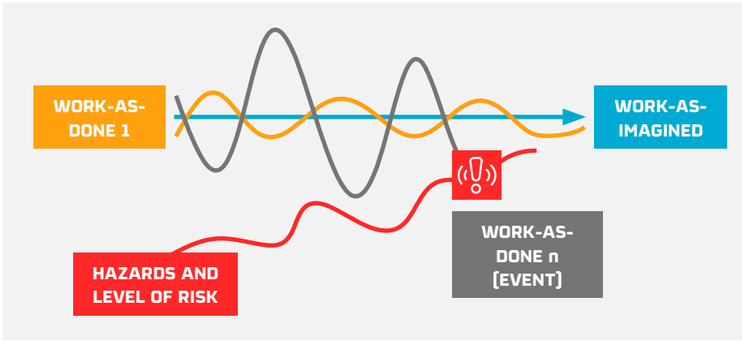
Rainwater had entered the manhole chamber of a tank. John and Anne, employees at a facility, had the task of draining the water. The gasket had come off, allowing water to enter. Oxidation of the pipes facilitated the entry of gases into the tank. Neither John nor Anne were qualified to enter a **confined space** and they were unaware that the manhole chambers were considered as such. Anne got inside, began to drain the water with a bucket, and lost consciousness. They did not measure the oxygen or the explosiveness in the manhole chamber, nor did they wear protective equipment. The adequate preparation and risk assessment had not been carried by the appropriate person in order to issue a work permit. Neither of them knew the rescue procedure.

There is a gap between the ideal planned circumstances and the actual operating conditions

People designing procedures expect them to be carried out exactly as written, in all circumstances. However, workers have to perform their tasks in a changing environment, which in some cases differs from the design conditions.

It is important to be aware of the differences and to reduce them in accordance with the hazards and level of risk, taking account of the realities and circumstances of executing the tasks, communicating concerns and stopping the operation if necessary.

We often wait and fail to change things until an incident occurs, by which time many constraints and deviations have already become normal practice. Do not wait. **Go ahead and identify these constraints** and manage them to prevent potentially hazardous situations.



Work-as-prescribed versus work-as-done

Steps to analyze errors

1

Identify errors in performance

If the operation deviates from the norm, identify the possible errors that could occur. An analysis of them will help you in identifying the factors later.

See human capacity and information processing

The **error** types are:

Unintentional errors

Individual and collective behaviors when the deviation of the action is **unintentional**.

- Slips
- Lapses
- Rule-Based mistakes
- Knowledge based mistakes

Non-compliance

Individual and collective behaviors when the deviation of the action **is intentional**.

- Induced by the situation
- Organizational optimizers
- Personnel optimizers

GEMS model
(Generic Error Modeling System)

2

Identify the factors or causes that contributed to the error

Never stop at the error! Analyze errors, delving into their causes and **identifying** the different types of **human factors contributing to each of them**.

See factor identification process

The **human factor** types are:

Organizational factors Objectives Organization Housekeeping Maintenance management Procedures and control of operations	**Software (S)** System Management and Organization
Management and monitoring factors Organization Maintenance management Procedures and control of operations	
Work factors Design Hardware Safeguards/ Barriers	**Hardware (H)** Design: machines and equipment
Workplace conditions	**Environment (E)** Environment conditions
Personal factors Organization Training	**Liveware (L)** Individuals
Communication	**Liveware (L)** Other people and groups

See human Factors

3

Identify and draw the interrelationships of people with their environment in the system

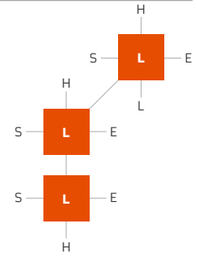
Having identified the human factors, analyze the interrelationships of the multiple components of the system, as if they were connected atoms.

Tool to analyze interactions

The **system components** are:

- **Software (S)**: System Management and Organization
- **Hardware (H)**: Design: machines and equipment
- **Environment (E)**: Environment conditions
- **Liveware (L)**: Individuals
- **Liveware (L)**: Other people and groups

Making this visualization will give you a better understanding of how the system works. The **interrelationships** are:

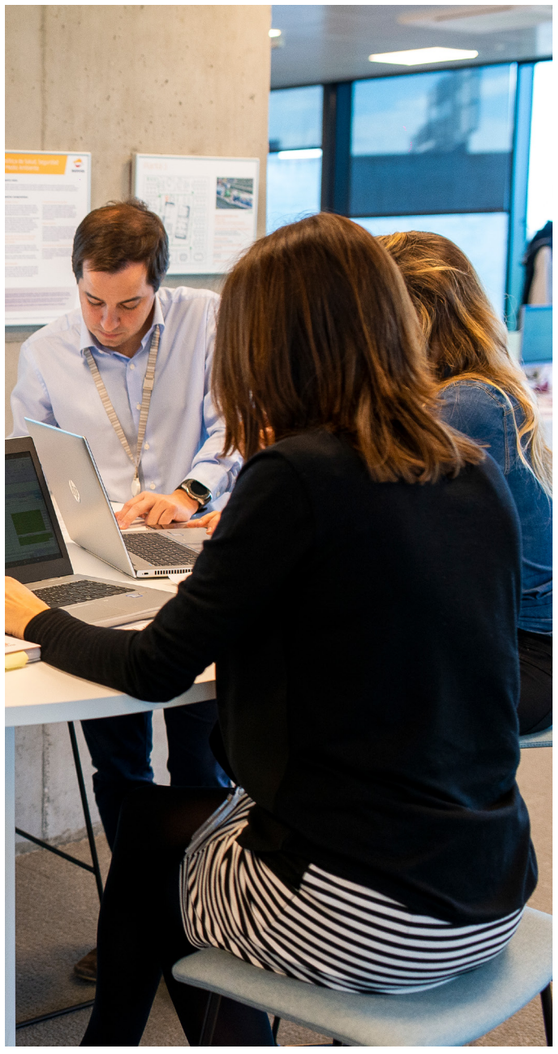


SHELL model
(Software, Hardware, Environment, Liveware, Liveware)

4

Take action

Act on each of the human factors identified to improve the system's operation and, ultimately, human and organizational performance.



PRACTICAL CASE

Example of analyzing the error and taking action to improve the system: overturned dump truck

Daniel, a worksite contractor, **fell asleep** while driving a dump truck on the way to unload. The truck collided with the median strip that separated the two lanes of the highway it was traveling on, causing it to overturn on one side.

1

What performance errors occurred?

Non-compliance
(organizational optimizers)

- Daniel felt very tired, but **he did not communicate his tired condition**. He had insistent orders not to delay the work.
- The unit did not verify **routine violation** of the basic safety standard on **taking rest periods into account when planning journeys**. The project's objectives took precedence.

Error
(Ruled-based mistake)

- The supervisor **did not identify or monitor** the fatigue risk.

2

What human factors contributed to the error?

Objectives (L-S)

- The works were very behind schedule. There was pressure to finish on time and **meet the project goals**.

Organization (L-S)

- It was **difficult** to find qualified drivers in the area, so the **work load was high**.
- The risk analysis **had not identified** fatigue as a hazard. Consequently, fatigue had not been taken into account in planning the work, rest times and the management of driver shifts.

Communication (L-L-H)

- **Communicating** situations of drowsiness on the part of the drivers, which had already occurred on previous occasions, was not encouraged.

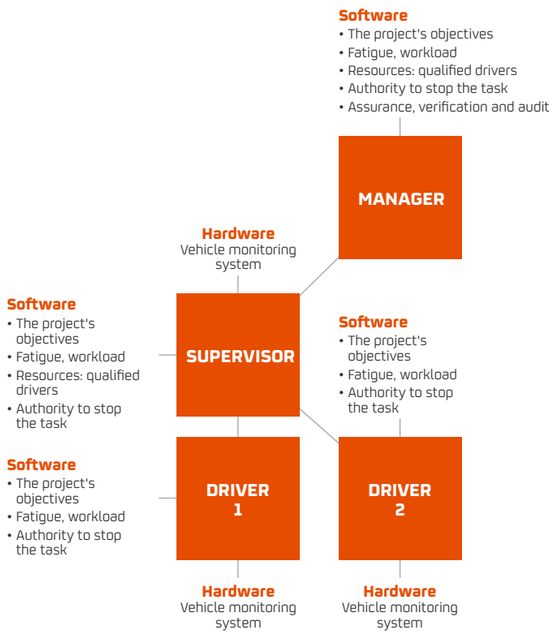
Procedures and control of operations (S-L-H)

- The managers had not established a **fatigue prevention system**, even though the **basic driving rule** gave instructions to prevent the hazard: "plan your trips considering rest periods." Authority was not established to **stop the task**, nor was **fitness to drive** verified.

3

What were the interrelationships between the various components of the system?

The following diagram of the different system actors and elements helps us understand the multiple interaction that occurs between the different participants to manage safety and monitor fatigue. Error should be understood as a normal part of any system where human beings and technology interact.



4

What action was taken?

1. A reinforcement program on "**safe mobility**" and "**safety leadership**"
2. Improved project planning and monitoring of the workday to adapt resources to the **workload** and works delivery times.
3. Promotion of **driver employment and qualification programs among contractors**.
4. Establishing **trust relationships** with contractor companies through, for example, safety seminars and workshops
5. Inclusion of fatigue in the **register of risk study hazards** as one of the hazards to be managed
6. Setting goals in line with best practices to manage fatigue in the **management system**.
7. Implementation of **authority for all employees to stop jobs** and communicate situations of fatigue.
8. **Improved communication and reporting** of situations of fatigue by drivers
9. Strengthened **reviews and audits**.

Generate knowledge and skills

To address human factors we must have the **same understanding of the concept of improving human performance** and of the changes and conditions that may influence our system. Only in this way can we integrate it into our work environments and extend it to our value chain.

Development roadmap

Organizations must have trained expert resources with knowledge of how to reduce risk by applying human performance tools and concepts relevant to their sphere of influence and with real-world application.

Basic skills can be acquired through a human performance training pathway.

See Energy Institute/CIEHF

Operational skill requirements

There are many tasks in a plant. We must direct more effort to tasks with greater potential consequences when carried out badly. Success in managing skills is based on **identifying safety critical tasks**, the worker's skills and the performance and assessment standards required for the task.

Tasks, learning needs and requirements are prioritized according to their criticality, complexity, frequency and the time available to complete them.

Task analysis serves to identify the type of skills and knowledge to be covered in the training's design. Equal attention should be paid to individual and team skills, with different methods to maximize their effectiveness.

Types of team learning:

- Coordination: joint team efforts to reduce risks.
- Cross-learning: team members learn the functions of other teammates.
- Self-correction: they review events, fix mistakes and discuss future strategies together.
- Event-based learning: trigger situations that provide opportunities to observe skills.
- Facilitated learning: stimulates learning by creating an effective practice environment, facilitating and encouraging discussions.

"To understand and improve the way that organizations work, we must in systems.

To meet demand and to balance conflicting goals in a complex and dynamic situation, staff need to make trade-offs and adapt to the situation. Performance will vary, it must vary to cope with varying demands and conditions.

To understand the system, we need to see it from the perspectives of the people who are part of the system."

Eurocontrol

Systems Thinking for Safety: Ten Principles

03

Good practices in the industry

Industry aspirations

Guiding principles

What do other sectors tell us?

Industry aspirations: integrate human performance principles into our operations

In 2021 and 2022, several workshops and meetings have been held between various energy industry organizations, under the banner "**Human Factors Summit**."

The objective is to work very closely with other organizations in the sector that want to be part of this effort, and together accelerate a set of **Human Performance principles**, through strategic alignment toward the same **industry goal**.

See organizations

The industry's goal

By 2025 we want every organizations in the energy industry to be able to say:

- The well-being of our workforce is a shared imperative.
- Our leadership demonstrates a culture of trust and inclusion by caring, listening to the workforce, making people feel valued for their contributions and supporting them.
- Human performance principles are embedded into how we design, operate and maintain our work environments, and we extended this across the whole supply chain and contributors.

We believe that, by working towards these aspiration, it lays the foundation for the daily delivery of safely and efficiently, it will enable an engaged and empowered workforce, and will allow us to safely supply the world with clean affordable energy."

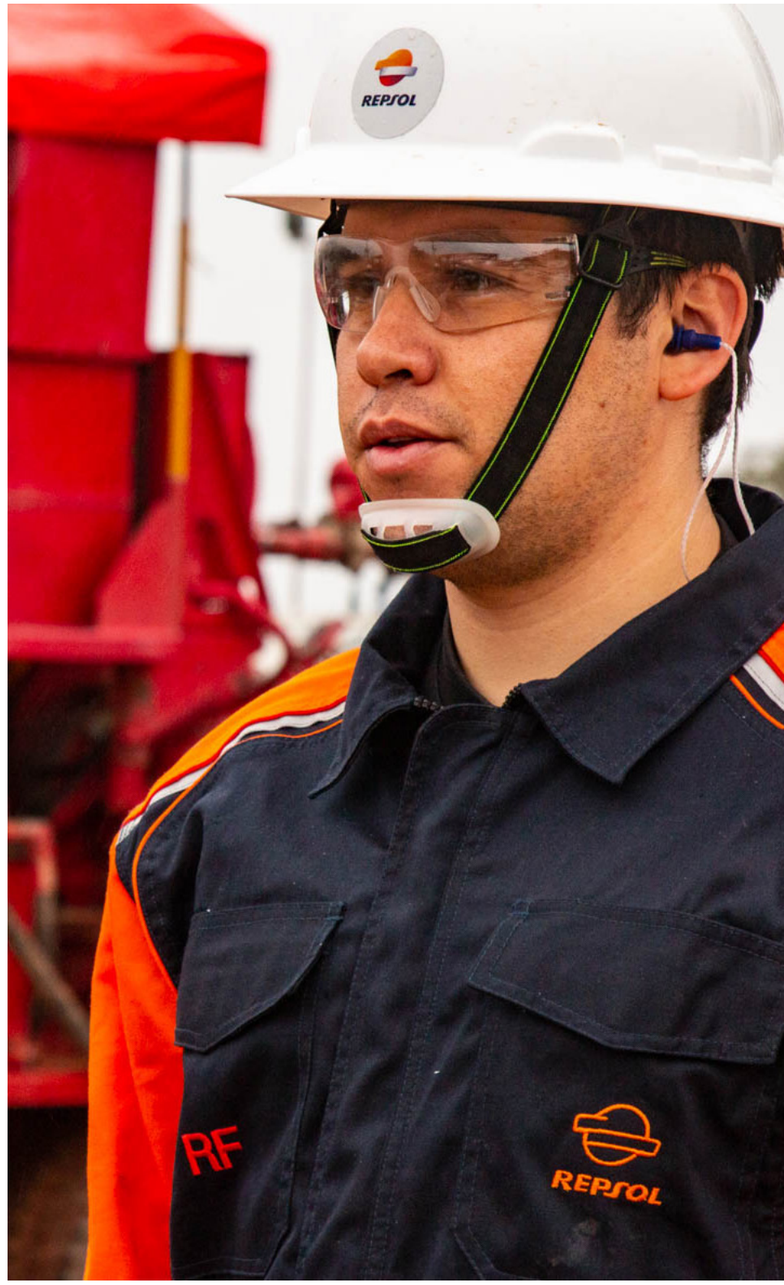
IOGP
Human performance vision

Well-being

The state people are in when their physical and mental conditions give them a **feeling of satisfaction and tranquility**. It is a general sensation in life that occurs on a physical, psychological and social level.

According to the World Health Organization (WHO), emotional well-being is a "state of mind in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community."

It is a **balance** of all parts of life: personal, work, social, sentimental, family and health.



Guiding principles of human performance

Call to action: principles

How can you make the difference? Adopt these simple, industry-recommended principles to achieve a paradigm shift and give a strong impulse to safety.

PRINCIPLES	EXPLANATORY STATEMENTS
Error is normal	☐ We all make mistakes ☐ We can predict or prevent, and we always have to manage error-likely situations
Blame fixes nothing	☐ Actions are rarely malicious, but well-imeaning behaviors intended to get the job done.
Context drives behavior	☐ Organizations influence their systems and people, and context drives behavior ☐ Majority errors associated with incidents stem from latent conditions
Learning is vital	☐ Understanding how and why of errors occur can help us prevent them ☐ How leaders respond to failure matters. We need to learn from mistakes
How you respond matters	☐ Our people are the masters of their job and the key to solutions ☐ People who feel valued are more engaged

Source: IOGP *"Human performance Principles" / Hearts and Minds, Energy Institute*

These principles or beliefs must be integrated throughout the organization since they are the foundations of the just culture necessary to improve human performance. Beliefs determine our behavior.

What do other sectors tell us?

Nuclear Industry

In response to the accident at the Fukushima Daiichi Nuclear Power Plant, Member States of the IAEA *[International Atomic Energy Agency]* issued a report the conclusions of which include:

"With a systemic approach to safety that analyzes the human, organizational and technical factors, an organization can be better prepared for an unexpected event.

Different disciplines within the behavioural sciences need to be involved, and it must be recognized that these experts are as educated and experienced in their areas of expertise as are the experts from areas such as engineering, physics and chemistry who have already contributed much to the nuclear community."

IAEA
"Human and Organizational Factors in Nuclear Safety in the light of the accident at the Fukushima Daiichi Nuclear Power Plant"

IAEA recommends a systemic approach to the analysis of human factors and to work with experts on the subject to create capability in the organization

Accident at the Fukushima nuclear power plant

Accident
On 03-11-2011, a major earthquake and tsunami in eastern Japan triggered a very serious nuclear accident. 3 of the 6 reactors in operation initiated an emergency shutdown. Power failed and emergency generators started, but a 15 m high tsunami inundated everything. The cooling system pumps were damaged and, as a consequence, 3 of the reactors melted down after 3 days.

Consequences
More than 100,000 people in a 20 km radius were evacuated. 2,259 died in the evacuation process.

Analysis
The risk assessment was inadequate, as it was done on a design basis, using historical rather than recent seismic data. Japan believed that its nuclear power plants were so safe that an accident of this magnitude was not credible. The underlying causes of the accident are in the organization and monitoring systems that supported wrong decisions and actions. So, the responsibility was collective and systemic, even cultural: the ingrained tendency of Japanese society toward obedience and insularity.

Aeronautical industry

The aeronautical industry has focused its attention for years on system efficiency and exploring the differences in the operational world between work-as-imagined and work-as-done. The ICAO *(International Civil Aviation Organization)* recognizes that member states should.

"Ensure the integration of human performance considerations in the planning, design and implementation of new technologies, systems and processes as part of a security management approach.

Promote and facilitate the integration of human performance elements within competency-based training programmes throughout the career of a professional.

Include strategies which promote safe, consistent, efficient and effective operational performance of the individual and across teams of individuals to address safety priorities."

ICAO
"Manual on Human Performance (HP) for regulators"

The ICAO assumes that the system has multiple interactions between its component parts.

Two plane accidents that caused the worldwide grounding of all planes of this model

Accident
On October 29, 2018, Indonesian Lion Air Flight 610 crashed into the Java Sea. On March 10, 2019, an Ethiopian Airlines flight met the same fate in a similar fashion.

Consequences
189 people died on the Lion Air flight and there were 157 deaths on the Ethiopian Airlines flight.

Analysis
Boeing executives were aware of the risks inherent in the Maneuvering Characteristics Augmentation System (MCAS) control system. It is an automated safety feature in the "Boeing 737 Max 8" aircraft model designed to connect itself automatically and make corrections if certain parameters are exceeded during maneuvers to change the altitude and heading. Both aircraft experienced erratic climbs and descents and fluctuating flight speeds before crashing shortly after takeoff.

After the first catastrophe, instead of grounding their planes until the source of the failure was determined, they blamed human error on the part of the Lion Air crew. The failure of the Ethiopian Airlines MCAS system further tarnished the Max's reputation and raised questions about whether it was really so robust. Boeing was forced to halt use of this model.

Safety accident indicators seem to be reaching an asymptote. Variations in the indicator are often influenced by factors such as production stoppages or the level of activity and not by safety improvements.

How can you contribute to improve safety?
Advancing in safety necessarily involves improving knowledge of what has already happened and taking preventive action, addressing the factors that influence human performance and integrating them in your day-to-day activities.

In this chapter, learn the approach and some of the basic ingredients that must be considered.

04

Opportunities for improvement

Work approach and framework

Production and performance in safety

Organizational and safety resources and culture

Operational safety pillars: dynamic environment of the activity

Work approach and framework

Improving **performance in safety and production** means optimizing communication and understanding of the needs between the different layers of the organization.

To achieve this, we need to be supported by the three **pillars of operational safety**: its **technical aspects**, the **safety management system** and **human factors**, all of which interrelate with each other. Everything is supported by the **resources and** the **safety culture** that exist.

Improving the organization's safety culture requires an integrated approach, with actions on all three pillars tailored to specific operational needs.

To achieve excellent performance, management must know what the operational front wants and needs to implement. What is the purpose of meeting the objectives? Are needs and shortcomings being dealt with on the operational front? What do operational personnel and contractors need to do their job well?

Technical aspects
Comprising the investment made in safety, worker participation in the design process, and the resources assigned to maintenance.

Safety management system
Comprising safety expectations and requirements. It must satisfy external requirements and those of the different actors, working together to prevent any hazardous situations that may occur.

Human Factors
Comprising improvement of all precursors that influence the performance of people within a system. People must be perceived as an individual and collective source of safety whose positive contribution must be encouraged through management of these factors.

Although technical aspects and the management system are inseparable from the organization, the greatest room for improvement, both in production and performance, lies in **human and organizational factors** based on a strong safety culture.

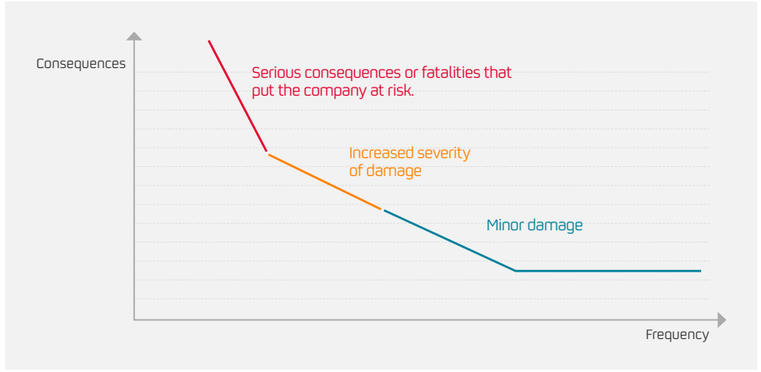
Remember

Production and performance in safety

Our actions must focus on processes that have an impact on the **most serious risks** and risks that threaten the continuity of operations. Accident rate indicators do not represent an absolute indicator of results in matters of safety. We must rethink how we define safety achievement, addressing hazards, reinforcing barriers and improving performance in the execution of critical operational tasks.

Reducing risk involves **recognizing new hazards that we had not previously identified and being on guard** against unexpected consequences.

Approaching human factors in a **preventive and proactive** way is vital for long-term surviving in environments where serious accidents are possible.

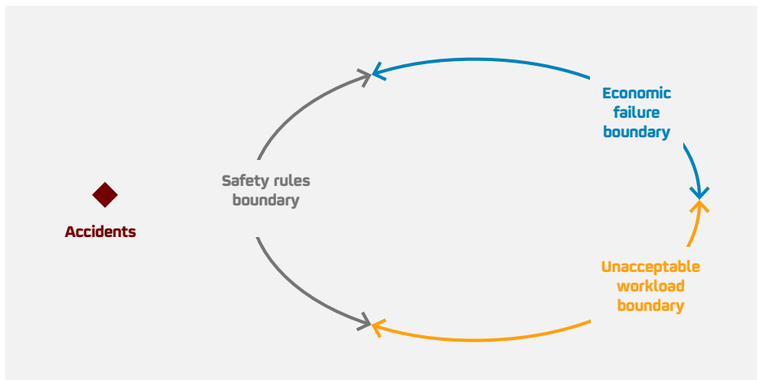


"Recognizing hazard and successfully manipulating system operations to remain inside the tolerable performance boundaries requires intimate contact with failure."

Richard Cook
How complex systems fail

Rasmussen's risk management framework

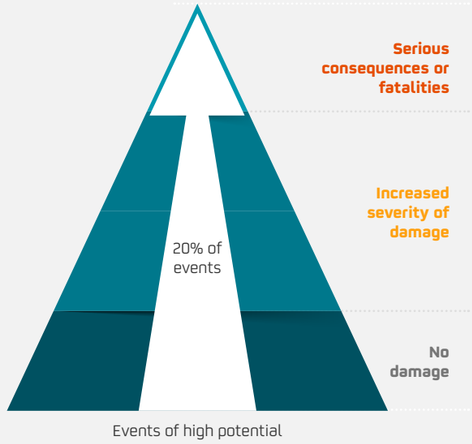
The economic boundary describes the operating envelope in which a business is profitable. The performance boundary reflects the human capacity in the system. If the system is stretched beyond its operating capacity, there may be disastrous results. Some room for maneuver has to be left to allow time to react to unexpected situations.



Focus on potentially serious events

Not all events have the same probability of generating a fatality.

Our focus should be on the 20% of events that may be precursors to major incidents, cause a fatality or have serious consequences, including process safety and basic safety rules.



The operational front is the best place to identify possible improvements to the system. Adopting the following fundamentals and rules contributes significantly to improving safety.

Process Safety Fundamentals

Take **all possible measures** to prevent deaths and serious accidents in all your activities. Adopt the fundamentals to reduce process safety incidents and help achieve this goal.

More information

Basic safety rules

The goal is to promote a **safe work environment** that helps to prevent situations of greatest risk in our activities.

More information

Organizational and safety resources and culture

The importance of reinforcing the safety culture

As part of our safety culture model, **leadership, trust in reporting, shared information, organization that learns, sense of vulnerability, adaptability and fair recognition** all facilitate an environment of rapid progress in human factors.

Our role as leaders

We must promote and embrace the principles of human performance to create the desired environment of trust and learning. We have the **responsibility to put our leadership in safety into action**. Because we can only thrive in a work environment we can trust, with tasks and systems designed to reduce the potential for error. And is the organization's culture that provides this.

Guiding principles of human performance

Leaders in safety

Those who promote or deploy responsibly behaviors that integrate safety.

Responsibility

Having the commitment to obtain a result and the ability to do what is necessary to achieve it.

If you are a manager, to be effective and act as a leader who supports a safe work environment, you must:

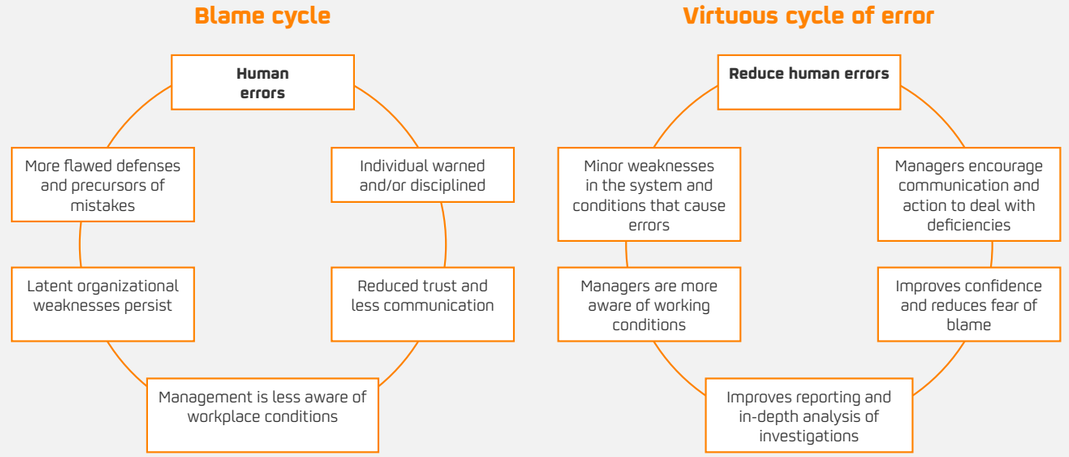
Foster an environment of trust and learning

Communicate and understand Do you know what your workers need to work safely? Do you promote organizational structures that favor communication? **Are you available in the field to talk to your team?** Do you listen to workers and take notice of their expectations? Do you support proactive action and early notification of problem areas?

Take decisions Are you active in identifying factors such as fatigue or stress in your work teams? Do you lead by example to promote a safety culture or a culture of "get the job done at any cost?"

Be proactive when something goes wrong Do you respond with empathy, putting yourself in the other's shoes, and with curiosity about the underlying problems when things go wrong? How do you react to receiving safety information, especially negative information?

Know your role and do not wait for an incident to occur before fixing a risk



DOE (U.S. Department of Energy) Standard - Human Performance Improvement Handbook

If you are an executive, practice safety-conscious leadership

Organizational structures should encourage employee participation. Improvements can be promoted by mapping of executives' objectives, organizational structures that place importance on the voice of experts, effective process safety indicators, improved risk awareness among managers and employees, and human factors management. Adopt principles of proper error handling through a just culture and an appropriate audit practice. Questioning, active and voluntary participation, and accountability for results should all be promoted.

Operational safety pillars: dynamic environment of the activity

Technical aspects, the **management system** and **human factors** constitute the pillars of operational safety and are strongly interrelated within a complex system.

To carry out their tasks, workers balance their actions and operational decisions according to the system pressures and the conflicts between objectives they come up against.

The processes, systems and equipment we use are not always suited to the dynamics of many different types of operations. An appreciation of human factors helps us to adjust tasks, systems and processes so that they are more operative in people's hands.

Throughout the life cycle of operations, from early development to decommissioning, workers are exposed to new and changing hazards, which often need to be managed in real time with a process of analysis and decision-making based on risk. People may find themselves in situations where they have to **make key decisions in adverse environments** to prevent or mitigate a serious accident.

Operational safety pillars

"A procedure is the mirror of the **theoretical and practical** knowledge of the operation of a process, valid in a certain moment. There is, usually, a gap between the procedure and the reality."

European Commission, 2007
Human and Organizational Factors in Nuclear Installations.

The system from people's perspective

To improve the safety culture we have to **understand how the system works** and see it from the perspective of the people who are part of it, **maintaining an ongoing dialogue about it how it actually operates**.

In areas with a higher probability of major accidents, dialogue can help us identify goals that put operating within safe limits at risk and can enhance the proactivity of managers in relation to safety actions, such as improving communication and the atmosphere of trust, managing changes and allocating resources to complete the work.

Regulatory environment and just culture

Establishing a just culture helps us to draw clear lines between what is and is not acceptable, but we must also bear in mind that a regulatory environment that is too rigid destroys capacity to adapt. The daily work of managers should be to consult their teams and promote an environment where people dare to speak up (psychological safety).

Empower workers

Performance will vary to deal with different conditions. In managing safety, we must give employees some leeway. **They need to feel that we trust in their criteria to deal with situations that may arise**.

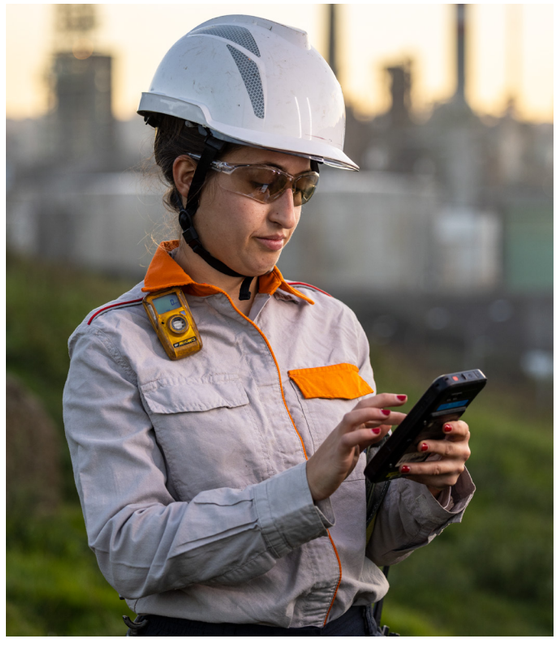
Workers create safety every day for their organizations, but we must always try to reduce the gap between work-as-prescribed and work-as-done. When conditions change, we must adapt and manage the risk

Prepare for emergencies

Ensuring that emergencies and crises are properly managed, with adequate planning and preparation of the response, allows us to eliminate or reduce the consequences of any undesired event.

If the difference between work-as-imagined and work-as-done is properly recognized and managed, **work can be adjusted for safety, so reducing risk and increasing reliability and workers' commitment**.

See areas for progress



05

Areas for progress according to your scope of action

To achieve a safer operation, within your scope of action, make it easier for people to succeed in their tasks.

The main objective should be to implement a system that guarantees that facilities and equipment are maintained and function properly.

We have to improve human performance and make progress in some key areas. Understanding human factors helps us to adjust tasks, systems and processes so that they are more effective.

Risk and human performance

Critical task management

Respond to dynamic situations

Learning and investigation

Management system

PRACTICAL CASE

Water jet cut

What happened?

While doing the preparation work for a new task to cut a hole in a tank using a water jet cutter, the cutting machine operator got into position behind the facility to observe and control the depth and direction of the cut. When the machine was turned on, a magnetic support in the installation came loose from the tank wall and the water jet began to swirl uncontrollably, lacerating his leg. It caught him by surprise. He had not been prepared to act in an emergency.

How do we prevent such incidents?

This chapter identifies some of the preventive actions that could have been taken. If a new plant is built, at the project design stage:

1. **Design, risk studies and task planning** should include the human perspective
2. **In operation** task management should be taken into account.
3. **If an emergency arises**, you have to be prepared.
4. **Learn during normal operation**.
5. **Incorporate all knowledge** in continuous learning and check for any gaps in your management system.

Risk and human performance: equipment and controls well designed and critical tasks identified

Risk analyses and the design of work environments should **adapt to human characteristics and the required tasks.**

Hear and address the difficulties that workers perceive as obstacles to doing their job well.

Our staff are masters at their work. They are the key to solutions and success in managing barriers.

Safety philosophy

In order to address potential issues, all risk management documentation (e.g., design philosophy or integrity) should incorporate the roles played both by workers on the operational front and the owners of barriers, functions and safety systems.

- Identifying the most serious hazards
- Identification and prioritization of safety critical tasks
- Planning, scheduling and understanding of tasks
- Assigning and breaking down critical tasks
- Indetifying errors and performance influencing factors
- Error control and error prevention measures / Job aids
- Pre-job meetings and briefings
- Work Procedures and Control, Work Permits
- Monitoring of the effectiveness of the measures and of the process

Human factors engineering in projects

Apply your knowledge of human factors to the design and construction of sociotechnical systems, throughout their life cycle, to optimize the human contribution. Designs have to support mental models. People are programmed to respond to information in a certain way and a good design must take account of our human capacity. **Performance standards** should be established to better understand and measure the effectiveness of critical barriers.

Safety critical tasks

Activities necessary for plant safety and prevention of serious consequences. These should be assigned to people who understand their role and responsibility. They include operational tasks, prevention, detection, control and mitigation and emergency response.

Human factors in risk studies

Risk studies should serve to identify hazards and the more serious scenarios. By analyzing them we can **identify and prioritize the safety critical tasks** that can affect them. In the analysis, it is important to understand the work and define the person's role and the possible errors, so that we can manage them. You can achieve this with the help of some techniques, such as hierarchical task analysis, Hazop with operator or supervisor failure causes, bow-tie, what-if and LOPA analysis, and fault and event trees.

The risks of facilities are usually **assessed under stable operating conditions**. Assessment of the **risks of transient operations**, such as shutdown or startup, **is equally important,** and these are often needed in order to be able to perform operational processes in which it is essential to understand the human factors that can contribute to errors. Take advantage of risk studies to assess risks in operating procedures, as well as in startup and shutdown scenarios.

Evaluation of errors in task planning and analysis

When planning a critical task it is important to be realistic about the time, complexity and effort required to carry it out. Take advantage of job planning and preparation for teams to discuss critical steps and pitfalls that can lead to situations of probable error (anticipated, unanticipated or latent). Planning can end with work instructions, a job safety analysis (JSA), a permit to work, or verbal briefings on the job and related safety issues. **Toolbox talks – SAFER**:

Synthesize the task
Anticipate high-risk situations
Facilitate preventing possible errors and mistakes
Evaluate planning of the task
Review preparation for the task

Revalidation and reassessment of risk analyses

Revalidations and reassessments of risk analyses of resources or activities must take into account modifications, management of change (MoC) and **operational information** as this knowledge can help us take a better approach to issues related to human factors, such as the human-machine interface. Our focus should be on understanding the process changes that have occurred and ensuring that the associated risks have been understood.

The human factor in organizational changes to operations

Need for early recognition of any change occurring in an operational, production, maintenance or logistics department that may affect human performance, since such changes can often contribute to serious accidents.

Opportunities and challenges of new technologies and automation

New technologies and automation are being adopted more and more in new and modernized safety critical systems and are helping to avoid many human errors (through automation, computerized documentation, safety functions, better interfaces, task and decision aids, data collection, etc). Nevertheless, at the same time, the nature of the system and of the work carried out by operators changes, so new safety problems arise. The system can become so complex that operators cannot understand its behaviors and decisions. Therefore, its adoption requires:

- **The identification of new error types** and influencing factors
- **The development of new ideas for interface design** that reduce mental fatigue, improve situational awareness, support task performance, provide decision-making aids and facilitate teamwork to reduce human error
- **Validation and comparison of interfaces designs**
- **Gathering of data** on human performance for better understanding and analysis

PRACTICAL CASE

Water jet cut

1. How to prevent risk and improve performance

While conducting a risk assessment for a new plant, Mary, a safety technician, asked the maintenance technician about hazards they may be overlooking. For example, the risk of high pressure water hitting an operator. In this way they identified the importance of:

- The machine's supports, which must not come loose and must be correctly maintained (some years ago an operator was injured). If the lance is not securely attached, the water can begin to swirl uncontrollably and lacerate an operator.
- Have a high pressure interlock that works correctly. Consequently, they reviewed all the safety devices needed in the equipment as safeguards.

They checked that this scenario is included in the studies and in the technical specifications, and that the machine's supports are included as **critical equipment** and their maintenance as a **critical task** for this type of machinery. A requirement was also included in the **permit to work system** to analyze this risk for this type of operations and to take it into account in the **pre-job assessments** that are carried out.

More information

Critical task management: well-executed tasks and procedures

We address human factors proactively with the aim of reducing the likelihood of an error occurring or, when it does, quickly detecting and rectifying it before it becomes a major incident. Process and engineering **procedures and controls only work** correctly **when designed with people in mind**, which means taking account of human variability when executing or interpreting the situation to ensure that the task is carried out safely.

Job aids

It is good practice to have an operating procedure for critical tasks. Procedures must be kept up to date. Job aids serve to show workers, in a practical and understandable way, the circumstances and conditions for using a sequence of actions. Assess the need for aids according to the criticality, complexity, frequency of the task and the time available to complete it. An aid must serve to assess a situation and take appropriate action.

Types of aid with operational information: manuals, instructions and checklists, work permits, shift change log, indicators and graphics, signage and labels, drawings, process flow diagrams, piping and instrumentation diagrams, etc.

Capture critical tasks and analyze them

Ensure that effective work controls have been put in place, that procedures are effective, that they are carried out according to the task design and that there is appropriate people management.

The importance of the role of managers

Managers must get involved and participate in dialogs about risks, foster an environment of trust, and understand the hazards and context of the situations and the decisions to be made. They must be critical, promote autonomy, responsibility and commitment in the team, facilitate learning and take responsibility for anticipating and learning from each event.

Fatigue and workload management

Fatigue reduces a person's ability to process information, lowers attention and alertness levels, impairs memory, reaction times and physical coordination, and potentially leads to errors.

Error handling techniques

- **Error detection tactics:** such as the verbalization activity or monitoring by a second person.
- **Thinking about the mistakes of others** can reduce the potential for error. This includes knowing how to provide and receive feedback, active listening, and being able to report errors without fear of repercussion.
- **Error recovery:** includes techniques such as questioning a perception, resetting the team, discussing the consequences of mistakes and encouraging collaboration.
- **Verifying the task:** self-verification, simultaneous verification in pairs, independent verification, concurrent verification by two people with separate confirmation of conditions.

WAI/WAD analysis

- Select a critical task or procedure and assemble your team to discuss it.
- Anticipate as best as possible. Detect and be aware of the gaps between work-as-imagined and work-as-done.
- Evaluate the gap based on circumstances and dynamics the environment.
- Reduce the gap between work-as-imagined and work-as-done based on risk.
- If you are a manager, adapt models and strategies according to circumstances.
- Prepare for any crisis or unforeseen event.

Look for strategies that allow you to approach changes as opportunities and know how deal with them in an objective and constructive way, taking advantage of their associated growth opportunities and, above all, be prepared.

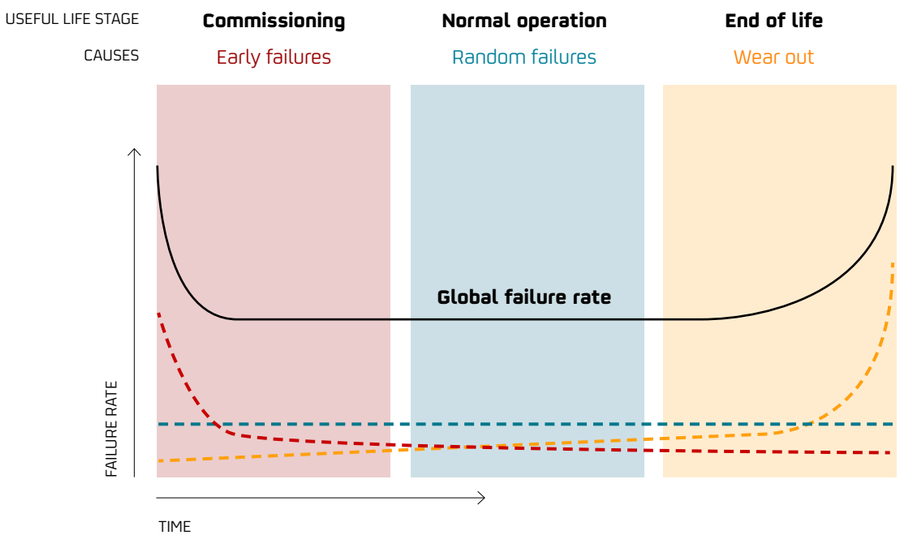
Walk Through Talk Through

WTTT *(Walk Through Talk Through)*. A technique based on human reliability for going through the steps in a job, one by one, and exploring the error traps in each step.

WTTT is not a behavioral observation technique, but is based on a dialogue with the person doing the work.

The bathtub curve

Widely used in reliability analysis to model the deterioration of facilities over time. Something similar occurs with people, who, although well trained and competent, are not infallible. With experience, our brain automates and optimizes information processing; we go from slow thinking to fast, expert thinking, which can also lead to errors. Everything we do must be accompanied by a strong sense of vulnerability. We must always be alert. If you go for a long time without any incidents occurring, do not let your guard down due to overconfidence, because if we normalize risk we stop seeing the threats around us.



PRACTICAL CASE

Water jet cut

2. How you can review a critical task.

The new plant had started up a year before and it was planned to shut it down to carry out some maintenance adjustments. The planned tasks included working at height to cut a hole in a tank using a high-pressure water jet cutter. John, the maintenance technician, knew that this task was hazardous due to the water pressure and that the work had to be done in a very controlled way.

He ran through the task with Joseph, the cutting machine operator, in the place where it was to be carried out. He was positioned behind the facility to be able to watch and control the depth and direction of the cut. The jet pressure was very high. The action protocol did not indicate that it was necessary to use personal protective equipment to prevent lacerations at that pressure.

They decided:

- That the operator closest to the work area should have control of the equipment's power supply and access to the disconnect switch.
- They proposed to update the protocol to use the personal protection equipment/shield suitable for these operations and work pressures, protect the area and prohibit the entry of all unauthorized personnel.

More information

Respond to dynamic situations

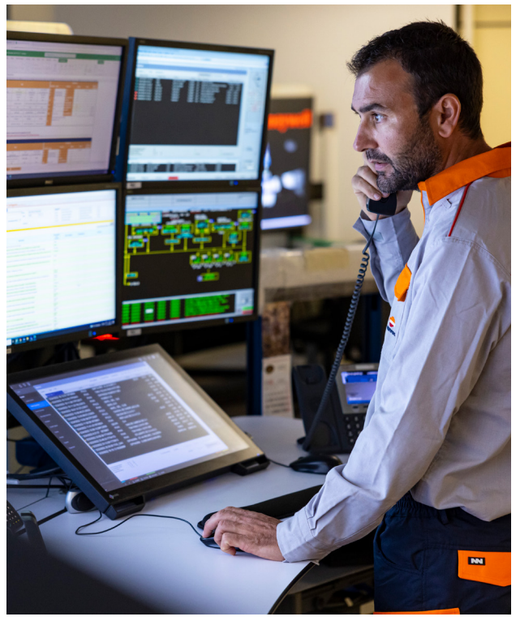
In addition to risk assessments conducted prior to a task, operational teams **must constantly identify and evaluate changes** in operating conditions, understanding the additional risks associated with these changes and stopping to consider control measures.

Help teams to work in dynamic conditions and to recognize and respond to unexpected situations, especially in environments where people may feel uncomfortable about raising their safety concerns, perhaps because they have not worked together previously or because they are unfamiliar with the facility's hardware and systems.

Contribute to providing teams with the means and systems to help identify, communicate and address problems before they become incidents, when something seems strange or a situation worries them.

Crew resource management

Refers to "cognitive, social and personal resource skills that complement technical skills, and contribute to safe and efficient task performance" (Flin & O'Connor, 2008). It focuses on **equipping the entire team with the skills and confidence to identify, communicate and address problems before they become incidents**.



Stop Work Authority

A safety process or procedure that authorizes and empowers employees to stop an action or a condition that they consider unsafe.

The goal of this plan is to encourage workers to speak up without fear of reprisal when they see a potential risk situation taking place.

Create a safe place to talk and, if necessary, stop the work. The use of SWA (Stop Work Authority) is not an easy action to take.

It requires effort, leadership, role modeling and skills, which must be prepared beforehand.

Develop skills to respond to emerging dynamic situations

The objective should be to improve the non-technical skills of all personnel involved in operations, with the focus on the following 6 key skills:

- **Situation awareness**
- **Decision-making**
- **Leadership/supervision**
- **Communication**
- **Teamwork**
- **Awareness of factors that influence human performance**

Situation awareness

Know what is going on around us and stay on the alert for the risks present in operations, based on information gathered from multiple sources in the task environment. Understand the meaning of this information and use it to anticipate what may happen next. This skill is very important in potentially hazardous work environments.

PRACTICAL CASE

Water jet cut

3. Be prepared to respond to dynamic situations

Before shutdown, the safety manager reviewed all critical jobs and their procedures. He realized that there was no emergency plan for these cutting operations and decided to incorporate one and establish **mandatory training** for operators and emergency teams in certain **non-technical skills** to help them detect hazardous situations.

These skills will help them identify technical problems, such as equipment deficiencies, design flaws or unauthorized workers in the area and, if necessary, **stop the operation**.

More information

Learning and investigation: learn before and after things go wrong

We have to anticipate and focus on learning from the normal operation and from the people doing the job before accidents happen instead of being reactive and waiting for them to happen. **Reacts to weak signals**, looks for concrete evidence to confirm or refute a problem. It is necessary to make sense of even the weakest signals to avoid underestimating or dismissing things that may turn out to be significant. Safety analyses, investigations and learning require a **just culture** to be of good quality.

Culture of learning

Ensure that learning is integrated. This requires focusing on reflective and proactive learning, not just on sharing. Remember that learning first requires a good quality analysis.

- ☐ Promote and reward continuous learning
- ☐ Give meaningful and constructive feedback
- ☐ Train employees
- ☐ Reserve time for learning
- ☐ Foster knowledge sharing

Learn from normal work

This is about maximizing the probability of the job going well. It is an effective way of reinforcing our safeguards before an event occurs to prevent any damage or loss.

Foster learning teams

An operational team is trained to learn from its tasks and improve the safety of operations by taking action. It aims to do this through dialogue, discussion, conflict management, emergency action routines and practice within the group. **Take advantage of this to learn from events and normal work and to discover the fragility that exists in our systems!**

Characteristics of high-performance learning teams:

- ☐ Understand the context of the incident
- ☐ Learn through active participation
- ☐ Learn from teammates
- ☐ Challenge the status quo
- ☐ Have a global vision of learning
- ☐ Learn from positive and negative events
- ☐ Shared or collective responsibility

Process of S&E lessons learned

Lead, internalize, share and act sustainably over time

Analysis and investigations: do not stop at the error

Go a step further in your investigations with structured processes and do not stop at the error to understand the situation and the context in which it occurred. When something goes wrong because someone has made a decision or taken an action that, in retrospect, seems imprudent it can be tempting to identify worker competence as the root cause.

For example, assigning tasks to people without the skills to perform them is usually organization's fault; it did not interview or train the worker, or provide resources, to the appropriate level. Even when a person is clearly qualified to carry out an activity, but does not do so, it is essential to explore the situation in which they found themselves and the factors that were the context for them to do what they did. **Errors become more probable due to the contribution of different factors influencing performance. The goal is to prevent other people from falling into the same trap**.

If we simply blame the person concerned, we miss the opportunity to prevent other workers from being influenced by the same factors and the error or incident being repeated. Behind an accident there are always multiple causes that contribute in different proportions, on which action must be taken.

Actions of the owner and the investigation team

Hindsight bias

A psychological effect that clouds our thinking. It describes how knowing the result changes the way we interpret the past.

It is the tendency of people to perceive past events as if they were more predictable than they really were.

It can cause investigations not to be of sufficient quality or depth because it stays among the assumptions held by the investigator, who may believe that the person concerned had more information than was actually the case or that the circumstances were different.

Information analysis

Analyze data from the normal operation and from incidents to understand problems related to human factors and latent conditions that contribute to the failure of any of the performance pillars, such as technical aspects, the safety management system and human factors.

Confidential Reporting System (CRS)

These systems are the result of the commitment of the entire organization and its personnel to risk reporting and safety improvement. The characteristics of these systems are that they are confidential, are managed independently of areas with disciplinary responsibilities or even external entities. It is supported by management and a just culture and integrated into the management system. It is designed based on a procedure that includes the use, communications, contents, taxonomy of events or facts, management, deadlines, actions, and feedback to employees, incorporating a powerful structure of information analysis. They allow reporting, among others: constraints, undesired conditions, errors, concerns, and non-compliances, failures to apply procedures, lack of qualification, lack of communication or information, fatigue, design, planning or execution defects or unsafe practices.

Employees should be aware of their advantages.

"All information received in the Confidential Risk Report system will be used exclusively for operational safety purposes, and retaliation or sanctions to personnel for the information submitted will be avoided, except in cases of gross negligence, malice or destructive behavior."

AESF - Spanish State Agency for Railway Safety

Restorative just culture

Its goal is to repair trust and relationships after an incident. It allows all parties involved to discuss how they have been affected and decide what needs to be done to repair the damage. The main objectives are moral commitment, emotional healing, reintegration of workers and operational learning.

Learn from past events

Explore the content of different high-risk situations and make use of the information found in daily tasks. It will help you and your team to get home safely. Also promote reflection about serious cases among your contractors. This helps to maintain the feeling of vulnerability and perception of risk.

Discover **52 serious incidents prepared by IChemE**. They help to improve process safety by sharing and communicating their lessons learned.

In addition, they highlight the importance of in-depth analysis. The one-page reports can be used at safety meetings to encourage reflection and discussion. They can also be hung as posters in the workplace to improve risk perception.

See cases

PRACTICAL CASE

Water jet cut

4. How to learn

Before the shutdown, the safety manager wanted to take advantage of the **safety meetings** to talk about **past serious incidents** related to future tasks to be carried out at the plant.

After searching for incidents related to pressurized water, he came across the video on "cleaning with pressurized water," which a refinery had made to cover the use of pressurized water to clean and unclog equipment at pressures greater than 250 bars.

He decided to make use of this lesson and go over it the teams, **to reflect on the tasks and work they do and identify if any further action** could be established.

More information

Management system: integrate human performance

It is important for reflections on human performance to be included in **projects**. However, it is perhaps even more important for them to be **integrated into the day-to-day of organizations,** in the daily approach and in people management as part of the way of doing business. Good integration requires total commitment on the part of the most senior managers in the organization. Start by adopting a policy and deploy it through the Safety Management System (SMS).

Integrating human factors helps ensure that methods and principles are applied appropriately and consistently during systems development to achieve a safe and efficient design for end users.

HSE Policy

Identify gray areas and possible areas for improvement

Make a short survey and ask people, face-to-face or through a questionnaire, if they have any problems with, for example, alarms, fatigue or procedures. Whenever possible, gather information on human performance issues: photographs, printouts, records, reports on incidents, skills, etc.

Consult your employees regularly

Culture diagnostics are an excellent tool for workers to communicate concerns and operational difficulties. They allow us to see and reduce the differences between what managers think is being done and what it is actually done. The identification of psychosocial risks in a team should lead to an analysis being made of possible difficulties in performing the work and a recognition of possible conflicts between objectives and available resources.

Human performance program

If you want to make progress on a bigger scale, we recommend adopting a Human Performance program to incorporate the subject's basic requirements in our Safety Management Systems (SMS). Some of the areas to cover are: engineering and design, procedure management, supply chain and contractor management, workload, stress and fatigue, safety critical communications, etc.

Safety performance indicators

Used to identify problems and improve performance. A balance between reactive and preventive indicators is recommended. Preventive indicators should guide us on the health of our management system, including feedback from workers. They should enable action to be taken to identify critical tasks, the demands of the job, and factors that influence and improve performance. Each asset or operation's chain of command should identify its own relevant quality indicators for monitoring.

Integrate human factors into specific projects

Whenever you can, integrate the human factors methods and procedures we have covered in this guide into specific projects.

More information

"The potential lack of familiarity that contractor personnel may have with facility hazards and operations poses unique challenges for the safe utilization of contract services."

Center for Chemical Process Safety

HUMAN FACTORS HANDBOOK FOR PROCESS PLANT OPERATIONS

Working with contractors

Some good practices that can help with the human factors in working with contractors are as follows:

- **Bidding documents** agreeing on the safety management elements to be used when cooperating on a project, contract or operation.
- **Planning and evaluation of safety at work:** identify in which parts of the work with the contractor the probability of error, lack of communication or confusion of roles and responsibilities increases.
- **Joint planning and evaluation of safety**
- **Support open communication:** being able to challenge or disagree without repercussions, ensuring reporting mechanisms for any unsafe conditions or events or potential risks, actively listening to contractors.
- **Mobilizing for task preparation:** includes activities such as: induction, familiarization with the customer and workplace, safety rules, risks, simultaneous operations, authority to stop work and fatigue requirements
- **Review of operational readiness to start work**
- **Coordination**
- **Double check on performance of tasks**
- **Demobilization activity** to ensure that the site is restored without omissions or communication errors.

PRACTICAL CASE

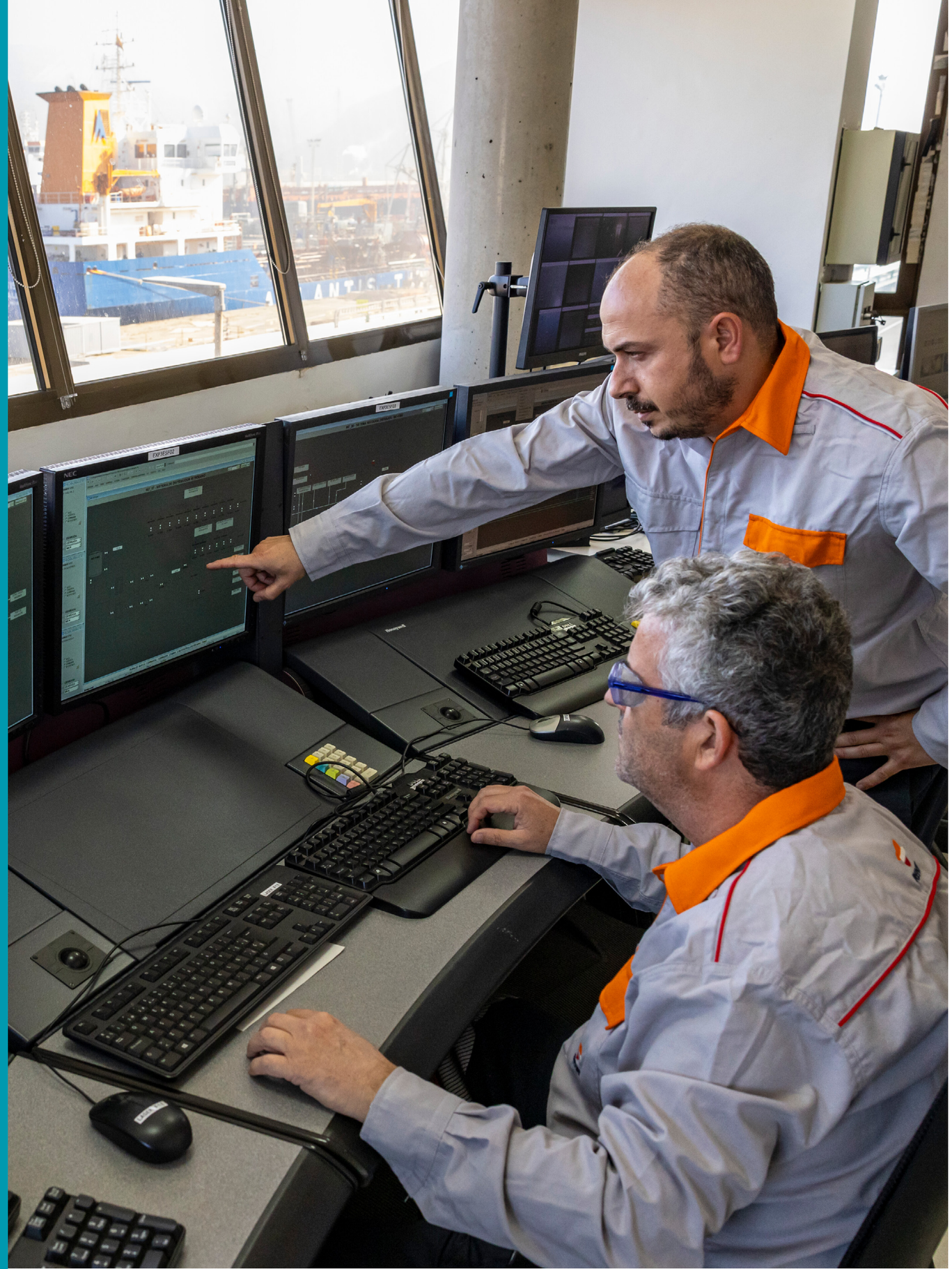
Water jet cut

5. How to improve the management system

During the shutdown, the preparation and all the actions taken previously had strengthened the barriers and prevented any damage from being caused. The plant's management team shared the actions with the managers of other assets. Taking advantage of the review that was to be made of the **management system**, they decided to incorporate some of these initiatives to encourage **personnel to participate in learning**.

06

References and initiatives



"Remember that things are not always as they appear to be... Curiosity creates possibilities and opportunities."

Roy T. Bennett

References to be up to date

Key human performance concepts (Chapter 2)

Key concepts

Energy Institute		Human and Organisational factors
Eurocontrol		Systems Thinking for Safety: Ten Principles A White Paper
HSE		Human Factors Key topics
HPOG		Glossary
ICSI		Organisational and human factors in safety
James Swanson		System Thinking and Your Organization
M. Johnson, A. Vera		No AI Is an Island: The Case for Teaming Intelligence
Richard I. Cook		How complex systems fail

People, design and technology

SINTEF		Automation and autonomous systems: Human-centred design in drilling and well

Steps to analyze errors

Skybrary		Generic Error-Modelling System (GEMS)
		Human Performance Modelling (HPM)
		ICAO SHELL Model
IADC Drilling Contractors		Why people don't follow procedures: a human performance perspective
		Why people don't see hazards: a human performance perspective

Human factors (Annex 2)

API		Process Safety Performance Indicators for the Refining and Petrochemical Industries
HSE		Performance Influencing Factors
Skybrary		Human Factors Analysis and Classification System (HFACS)
Tripod		Tripod Delta: Proactive Approach to enhanced Safety, Journal of Petroleum Technology
		Tripod Lite

Generate knowledge and skills: recommended training

CCPS		Guidelines for Defining Process Safety Competency requirements
CIEHF/EI		Specialization in human factors "Human Performance Pathway"
HPOG		Competencies by role
IChemE		Process Safety Competency Guidance

Good practices in the industry (Chapter 3)

Main reference guides

IOGP		Understanding and managing human factors in the wells sector
OCIMF		Human factors approach

Guiding principles

IOGP		Human performance Vision
Todd Conklin		The 5 Principles of Human Performance
Toolbox		"Being Human" – Hearts and Minds

Energy industry organizations

Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP)
American Petroleum Institute (API)
Bureau of Safety and Environmental Enforcement (BSEE)
Energy Institute
Foro Marítimo Internacional de Compañías Petroleras (OCIMF)
HeliOffshore
Human Performance Oil&Gas (HPOG)
International Association of Drilling Contractors (IADC)
International Association of Oil&Gas Producers (IOGP)
International Marine Contractors Association (IMCA)
International Regulation Forum
International Well Control Forum (IWCF)
NOPSEMA (Australia's Offshore Energy Regulator)
Petroleum Safety Authority Norway (PTIL)
Society of Petroleum Engineers (SPE)
Step Change in Safety

What do other sectors tell us?

IAEA		Learning from Fukushima Daiichi: Factors Leading to the Accident
ICAO		Manual on Human Performance (HP) for regulators
National Diet of Japan		The Fukushima Nuclear Accident Independent Investigation Commission
Nuclear And Radiation Studies		Lessons Learned from the Fukushima Nuclear Accident
Rory Kennedy		Downfall: The Case Against Boeing i 2022
FONCSI		Human and Organisational Factors Practices and Strategies for a Changing World:
CANSO		NORMAL OPERATIONS MONITORING TOOLBOX

Opportunities for improvement (Chapter 4)

Work approach and framework

ICSI		The essentials of safety culture

Production and performance in safety

IOGP		Life saving rules
		Process Safety Fundamentals
Repsol		Process safety – The importance of prevention [Process safety, prevention is key]
		People's safety: the 10 Basic Safety Rules [People's safety - 10 Basic safety rules]
Tom Connor		Boundaries of failure - Rasmussen's model of how accidents happen

Organizational and safety resources and culture

Andrew Hopkins		Failure to Learn: The BP Texas City Refinery Disaster
		Organising for Safety: How structure creates culture
		Disastrous Decisions: Human & Organisational Causes of the Gulf of Mexico Blowout
CCPS		Process Safety Leadership from the Boardroom to the Frontline
		Essential Practices for Creating, Strengthening, and Sustaining Process Safety Culture
DOE U.S. Department of Energy		Handbook -human performance improvement
IOGP		Safety Leadership in practice
		Shaping safety culture through safety leadership
Repsol		Libro blanco de Cultura de Seguridad [Safety Culture White Paper]
Safety Science Paper		Storytelling or theory building? Hopkins' sociology of safety

Operational safety pillars: dynamic environment of the activity

European Commission, Joint Research Centre,Institute for Energy		Giustino Manna - Human and Organizational factors in Nuclear Installations
CCPS		Human Factors Methods for Improving Performance in the Process Industries
		Conduct of Operations and Operational Discipline: For Improving Process Safety in Industry

Areas for progress according to your scope of action (Chapter 5)

CCPS		Human Factors Handbook for Process Plant operations

Risk and human performance

CCPS		Guidelines for Integrating Process Safety into Engineering Projects
		Guidelines For Preventing Human Error In Process Safety
		Guidelines for Safe Automation of Chemical Processes
		Guidelines for Asset Integrity Management
		Bow Ties in Risk Management: A Concept Book for Process Safety
		Guidelines for Process Safety During the Transient Operating Mode
		Guide for Making Acute Risk Decisions
		Guidelines for Managing Process Safety Risks During Organizational Change
		Guidelines for the Management of Change for Process Safety
Energy Institute		Managing major accident hazard risks during organisational change
		Guidance on human factors safety critical task analysis
G. Salvendy, W. arwowski		Handbook of Human Factors and Ergonomics
HSE		Human Factors in Risk Assessment
		Review of human reliability assessment methods
		The health and safety toolbox: How to control risks at work
IChemE		Guide to Delta HAZOP
IOGP		Human factors engineering in projects
		Start Work Checks
		Standardization of barrier definitions
		Human factors in QRA
		Asset integrity 2008
		Land transportation safety - journey management
		Lifting and hoisting recommended practice
		Oil and Gas Aviation Recommended Practices
OnePetro		Human Factors in Hazard Analysis
OESI		Human Factors and Ergonomics in Offshore Drilling and Production: The Implications for Drilling Safety

Critical task management

CCPS		Dealing with Aging Process Facilities and Infrastructures
Energy Institute		Managing fatigue using a fatigue risk management plan (FRMP)
HPOG		WTTT Technique
IOGP		Managing fatigue in the workplace

Respond to dynamic situations

Energy Institute		Guidance on CRM
IWCF		Well Operations Crew Resource Management Awareness (WOCRM) Free Course
IOGP		Crew Resource Management for Well Operations teams
		Guidelines for implementing Well Operations Crew Resource Management training
		The use of behavioural markers of non-technical skills in oil and gas operations
		Mental health risks and the COVID-19 pandemic
LQM		HF Model - Non Technical Skills Assessment Form

Learning and investigation

CCPS		PSID Process Safety Incidents Database
		Driving Continuous Process Safety Improvement From Investigated Incidents
		Book of Beacons
		Incidents That Define Process Safety
		More Incidents That Define Process Safety
		Guidelines for Investigating Process Safety Incidents
		Recognizing and Responding to Normalization of Deviance
		Recognizing Catastrophic Incident Warning Signs in the Process Industries
Energy Institute		Toolbox - Free to use incident lessons
		The modern view of incident causation
IChemE		Learning lessons from major incidents
IMCA		Safety Flashes
AESF		Guidance for the implementation of safety culture in Safety Management Systems - Confidential Risk Reporting (Spanish)
IOGP		Components of Organizational Learning From Events
		Demystifying Human Factors: Building confidence in human factors investigation
		Learning from normal work
		Data Sharing Guidance
		Safety Reports
Keil Center		Human Factors Analysis Tool
M. Nazaruk		Learning From Normal Work
		Difference Between Learning from Normal Work and Risk Assessment
Repsol		A key element to continue improving: Lessons learned- Process and method
S. Dekker		Do Safety Differently
Skybrary		James Reason HF Model
		PEAR Model
		Generic Error-Modelling System (GEMS)
		Human Performance Modelling (HPM)
Sologic		Análisis de causa raíz (Root cause analysis)
TapRoot		Incident investigation fundamentals
Tripod		Tripod Beta
		Tripod Lite
Urban Utilities		Learning Teams Workshops

Management system

CCPS		Guidelines for Risk Based Process Safety
		Process safety Publications
COMAH		Inspecting Human Factors at COMAH Establishments (Operational Delivery Guide)
Energy Institute		Briefing Note No. 16 - Human Factors Integration
		Human factors briefing notes and publications
HeliOffshore		HeliOffshore safety resources
HPOG		Empezar con desempeño humano (Start with human performance)
		Human factors briefing notes and publications
		HP in Your Management System
ICSI		Human and organizational factors
IOGP		Operating Management System Framework
		OMS in practice. Operating Management System Framework
		Process safety - recommended practice on key performance indicators
		HSE management guidelines for working together in a contract environment
		Fabrication site construction safety recommended practice
		Fabrication site construction safety recommended practice – Enabling activities
Onshore Safety alliance		Onshore safety alliance
Repsol		Safety and Occupational Health Policy
SPE		Live webinars
		Are you applying human factors / human performance as per the industry guidance?
Step change in safety		Human factors online assessment tool
		Human Factors Workgroup

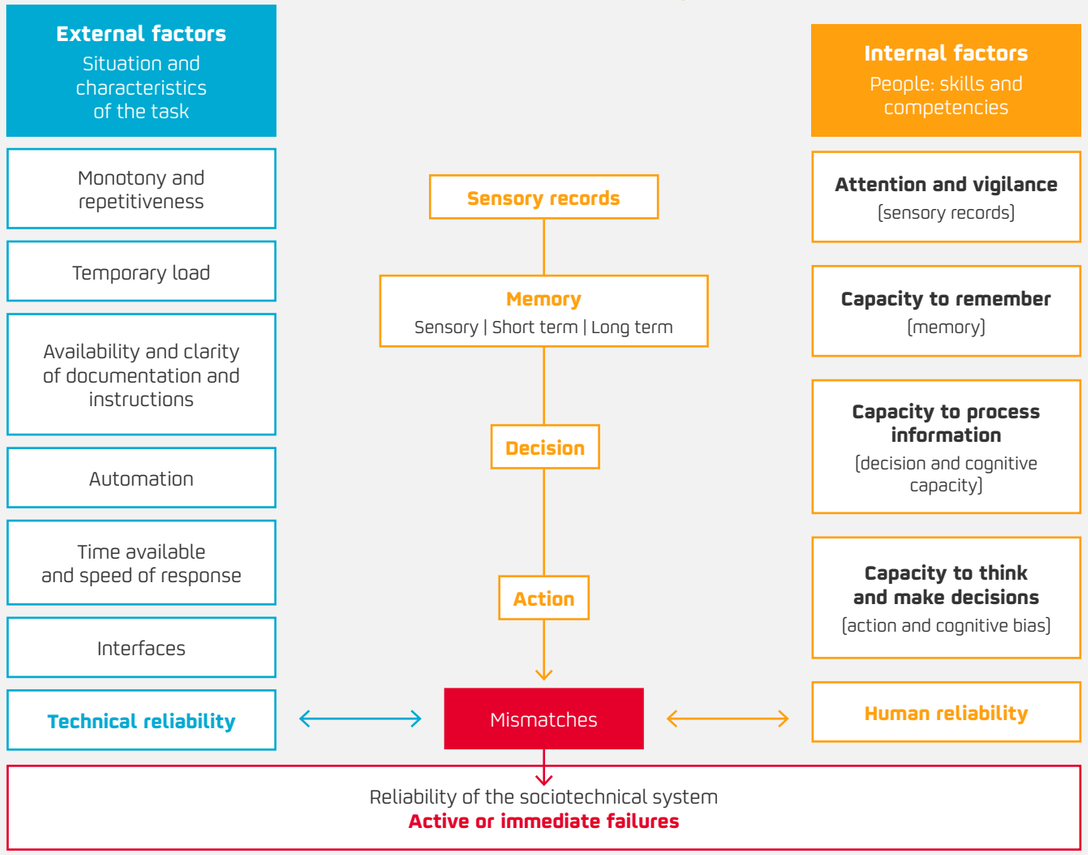
ANNEX 1

Human capacity and information processing

To improve human performance, it is important to understand the demands of the tasks and the limitations of human capacity.

Human performance is affected by cognitive abilities, or the way we think and process information. Errors arise from **mismatches** between people's capabilities and the physical and mental demands of the job. In general, error is an unintended result of our sensory processing of the environment, our memory, our cognitive capacity and how we take action. Moreover, all systems of thought and decision-making can lead us to reinforce errors due to **cognitive biases**.

Task versus activity



Types of memory

- **Sensory memory:** The brain process that interprets stimuli in milliseconds.
- **Short-term memory:** Our main processor of work. Automatic, fast, efficient and intuitive, with which we usually function. Using it consumes less energy, but it can lead us to wrong decisions.
- **Long-term memory:** Capacity to memorize information for a long time. It requires a conscious effort and continuous attention. Using long-term memory requires more effort, but it allows us to analyze and solve problems.

Cognitive capacity

It is the amount of information that we can process for a task. It influences our performance of a task depending our mental load.

Cognitive bias

Systematic misinterpretation of information influencing the way you process thoughts, make judgments and make decisions.
The concept was introduced by the Israeli psychologists Kahneman and Tversky, in 1972.

Cognitive heuristics

To process complex information and make quick decisions we tend subconsciously to use necessary cognitive shortcuts or learned rules. For example, if we do not have enough information, we make estimates based on our intuition to avoid situations of uncertainty.

Human reliability

The probability that a task can be completed successfully. Its evaluation takes the form of modeling and estimating the probability of the human performance being satisfactory, mainly in relation to the operation of industrial systems.

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ANNEX 2

Process to identify factors associated with an error

1
Identify the type of action

2
Identify preconditions

3
Identify factors related to monitoring

4
Identify organizational influences

Individual actions and decisions

Unintentional errors

Individual and collective behaviors when the deviation of the action is **unintentional**: slips, lapses, rule-based mistakes or knowledge based mistakes

Violations

Individual and collective behaviors when the deviation of the action **is intentional**: induced by the situation, organizational and personal optimizers

Preconditions

Work factors

Personal factors

Management and monitoring factors

Organizational factors

Human performance

Action or inaction in a task: human errors

Human factors

Human performance constraints, error traps: situation or context

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ANNEX 3

Human factors

Sea system areas

Human factor references

Organizational factors

Organizational culture

Organization	**Climate, organizational structure and policies**	■ Safety leadership and culture ■ Organizational structure ■ Policies

Operational process

Objectives		■ Definition, measurement and evaluation
Organization		■ Implementation of processes (learning, taking action, verification, assurance and audit) ■ Risk management (identification, management, communication) ■ Contractor management
Housekeeping		■ Order and cleanliness
Maintenance management		■ Inspection plan ■ Maintenance plan ■ Temporary repair or repetitive failure
Procedures and control of operations	**Processing**	■ Existence and availability of the procedure ■ Clarity of documentation and instructions ■ Design of tasks and procedures
	Work permits	■ Issuing the work permit ■ Quality of the work permit ■ Ending the work permit
	Management of Change	■ Launch of the management of change process ■ Type of management of change ■ Execution of management of change. Temporary changes ■ Training or information on management of change ■ Review and authorization prior to commissioning
	Emergency response	■ Identification of scenarios in emergency plans ■ Emergency response

Resource management

Organization	**Human resources**	■ Selection and allocation of staff. ■ Implementation of processes. Training catalog. Undefined training ■ Competence assurance
	Equipment and facility resources	■ Resources for design and adaptation of equipment/facilities ■ Rationalization of alarms
	Financial resources	■ Financing of the activity ■ Cost management
Maintenance management		■ Resources for maintenance of equipment and facilities
Procedures and control of operations		■ Facility and equipment resources for emergency response

Management and monitoring factors

Organization	**Follow up of operations**	■ Follow-up and monitoring of work ■ Working in the wrong place ■ Simultaneous operations ■ Stop work
	Behavior of executives and supervisors	■ Lead by example and communicate ■ Provide responsibility
	Scheduling of operations	■ Provide resources ■ Planning and risk assessment ■ Verification of risk controls
Maintenance management		■ Supervision/Quality of maintenance work
Procedures and control of operations		■ Implementation of procedures and monitoring of operations: errors and violations ■ Monitoring the use of work permits: errors and violations

Work factors

Design	■ Process conditions ■ Ergonomic factors ■ Operator interface and automation ■ Design standards: design of the workspace (confined, accessibility) ■ Design safeguards and interlocks ■ Change management during construction ■ Signage, warnings and labels
Hardware	■ Condition of tools
Workplace conditions	■ Physical environment: weather conditions, natural or land disasters, cold, heat, noise, lighting, hazardous atmosphere, and chemical, biological and radiation hazards ■ Temporary physical, mental or psychological capacity limits: high workload, stress, fatigue
Safeguards and barriers	■ Operator controls: definition of alarms and operating limits ■ Operator controls: availability of a safety instrumented system safeguard and operating limits ■ Personal protection equipment ■ Tool and machine guards

Personal factors

Organization	■ Mental conditions: workload, stress, distraction, etc. ■ Physiological conditions: fatigue, illness, etc..
Training	■ Mental states, temporary mental and psychological capacity ■ Temporary workload and stress ■ Training and knowledge ■ Experience or skill to work ■ Perception of risk
Communication	■ Coordination and planning, teamwork, collaboration, team situation awareness ■ Effective communication: shift change, field and panel instruments, pre-task briefing, coordination ■ Dissemination of improvement actions or lessons learned

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ANNEX 4

Actions of the owner and the investigation team

Owner

Who?

- The person who requests the investigation and/or receives its results.

What must they do?

- Facilitate resources and access to information.
- Avoid bias. Be aware of how their own influence may affect the incident and investigation.
- Help preserve the independence of the investigation team.
- Ask for analysis of how organizational and human factors influence people's behavior.
- Encourage a thorough investigation and open and honest reporting.
- Support learning, taking action constructively and questioning what happened.

What must they not do?

- Talk about who is to blame or include disciplinary procedures.
- Guide the investigation toward their own conclusions.
- Fail to share the results with other leaders.

Investigator

Who?

- The person who leads or performs the investigation and draws conclusions.

What must they do?

- Keep an open mind.
- Analyze the entire case to avoid bias.
- Base all conclusions on the evidence found.
- Always put yourself in the place of the person who made the mistake.
- Understand people's behavior and analyze how the environment, organization and procedures influence the performance of tasks.
- Focus on preventing the event from happening again and identify critical tasks.
- Propose actions to reduce risk and improve barriers.
- Use clear language to explain what happened.
- Present the facts in a way that facilitates taking action.

What must they not do?

- Focus on the person who made the mistake rather than on the context that contributed to its occurrence.
- Relate the investigation to disciplinary procedures.

Premises or terms of reference for analysis: events of high potential

The premises provide the basis for **events of high potential** regarding what the leader should do and how the analysis should be conducted, **signed by the owner of the analysis**.

The analysis must be conducted in a **fair, impartial and timely** manner. The goal is not to "build a case" against an area or certain individuals, but to establish facts and, by applying policies and standards to such facts, make recommendations with the aim of taking an **in-depth look at the factors that can help to prevent potentially serious errors** and **identifying areas for improvement in our organization**. It should reflect the fact that the investigation's scope **does not include disciplinary procedures** and that the findings and possible **lessons will be shared** openly and honestly with other leaders.

It includes information on the **roles of the different people** involved, **work deadlines** and how to manage human resources in the investigation, so that participants are clear about their role and the necessary resources.

Given the possible inherent sensitivities in investigations, especially when serious damage has occurred, it is important that all persons involved in this process respect confidentiality and exercise discretion. The investigation's leader is responsible for modeling these behaviors and ensuring that the witnesses interviewed understand the purpose of the analysis and that they must also respect its confidentiality.

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