Human and organizational factors of safety : state of the art.

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HUMAN AND ORGANIZATIONAL FACTORS OF SAFETY

STATE OF THE ART

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FONDATION POUR UNE CULTURE DE SÉCURITÉ INDUSTRIELLE

The *Foundation for an Industrial Safety Culture* (FonCSI) is a french public-interest research foundation created in 2005. It aims to:

- undertake and fund research activities that contribute to improving safety in hazardous organizations (industrial firms of all sizes, in all industrial sectors);
- work towards better mutual understanding between high-risk industries and civil society, aiming for a durable compromise and an open debate that covers all the dimensions of risk;
- foster the acculturation of all stakeholders to the questions, tradeoffs and problems related to risk and safety.

In order to attain these objectives, the FonCSI works to bring together researchers from different scientific disciplines with other stakeholders concerned by industrial safety and the management of technological risk: companies, local government, trade unions, NGOs. We also attempt to build bridges between disciplines and to promote interaction and cross-pollination between engineering, sciences and the humanities.

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Foreword

Over time, in order to manage industrial risks, companies have developed measures aiming continually to improve the reliability of facilities and the implementation of safety management systems. Whilst there is no question that significant progress has been made, safety results seem to have reached a plateau and further progress requires human and organizational factors to be taken into account.

However, achieving such changes will not happen automatically:

- the industrial approach still tends to focus on the behaviour of operators, on human error and on compliance with procedures, neglecting the positive contribution of humans to safety and limiting the understanding of deeper yet essential causes;
- companies often have a pronounced technical culture and very rarely possess in-house expertise in the area of human and organizational factors of safety;
- there have been few reference documents published with the aim of facilitating the transfer of scientifically acquired knowledge to those involved in safety (industrial companies, trade unions, regulators, *etc.*).

In short, including human and organizational factors in industrial safety policies and practices means drawing on new knowledge from the human and social sciences (ergonomics, psychology, sociology and others), and finding ways to link this with concrete operational issues. The aim of this document is to respond to this need. It is the result of the work of a number of people over several phases:

1. As part of its call for proposals concerning "technical, human and organizational vulnerabilities and the quest for safety", the *Fondation pour une Culture de Sécurité Industrielle* (FonCSI, Foundation for an Industrial Safety Culture) selected and funded a team of recognized researchers with extensive experience in high-risk industries (nuclear, petrochemical and transport).
2. The researchers produced a document based on their scientific expertise, according to a structure tested in training sessions run by the *Institut pour une Culture de Sécurité Industrielle* (ICSI, Institute for an Industrial Safety Culture) about human and organizational factors and aimed at site managers, members of management teams and trade unions.
3. This document formed the basis for numerous discussions with operational stakeholders from a variety of backgrounds (industrial leaders, union representatives, specialists from research or expert institutes, *etc.*) brought together as part of the ICSI discussion group on human and organizational factors of safety.

As a result, this original approach makes it possible to propose a frame of reference that is common to all industrial safety stakeholders who wish to reinforce their preventive measures by giving better consideration to the role of the individual and the organization.

Toulouse, April 7th 2009
Ivan Boissières, ICSI

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We are interested in your feedback! Please send any comments or suggestions for improving this document via email to `cahiers@FonCSI.org`.

For information about the other programmes ICSI offers in conjunction with its partners to encourage the consideration of human and organizational factors in safety practices, and which use this document as their frame of reference (short courses, specialist executive masters, practical guides, *etc.*), you can also visit ICSI's web site: www.icsi-eu.org

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Note that the original French version of this document is freely downloadable from ICSI's web site.

Contents

Preamble

This document

- Provides a first summary of knowledge about human and organizational factors of industrial safety.
- Will be followed by other guides suggesting methods for taking this knowledge into account.

Its target audience

This guide aims to provide a **common reference framework** to all those involved in the field of industrial safety:

- group-level safety managers;
- industrial directors;
- unit or industrial site directors;
- site environmental safety managers, workplace health and safety professionals;
- human resources managers;
- managers in charge of industrial policy for subcontractors;
- operations managers;
- trade union representatives;
- inspectors working for public authorities and regulators;
- internal and external consultants.

Its scope

Companies concerned by **major accidental hazards** (process industries, nuclear industry, transport sector),

- that in the course of their activity are likely to generate risks for their employees and also for the general public and the environment;
- that have already put in place a general safety policy, with the implementation of a Safety Management System (SMS[1]), put in place safety standards (for example OHSAS 18001) and regularly undertake audits (using frameworks such as ISRS®).

This document does not cover regulatory requirements, the formal components of the SMS or standard audit criteria.

Companies that have not developed this formal approach to safety should not be under the illusion that the human and organizational factors approach to safety presented here is a substitute. However, familiarity with the elements put forward in this guide can help to improve the implementation of a SMS.

Occupational safety and industrial safety

prevention of process-related accidents

The scope of "industrial safety" as it is explored in this document covers the **prevention of process-related accidents**, whether these are likely to affect the facilities, the employees of the company, the environment and/or the general public. Preventing industrial accidents is, of course, the responsibility of operators, but also of a number of other departments within a company (including, for example, purchasing or human resources).

[1] Abbreviations are defined in a glossary at the end of this document.

This guide therefore does not cover the entire scope of "occupational safety" in the sense of preventing occupational accidents. Certain occupational accidents have origins that could lead to an industrial accident: *an operator falls when rushing to close a valve that plays a critical role in the process.* Others, which could have the same effects on the employee, are caused by something far removed from the technical processes of the company: *an operator falls downs the stairs of the administrative building.* Preventing these types of accident is also important, but is not covered by the scope of this guide.

Preventing occupational accidents does not necessarily prevent major industrial accidents

While there may be a link between the causes of occupational accidents during operations and those of major industrial accidents, it should be emphasized that the "safety performance" of a site, expressed as a cumulative occupational accident incident rate, tell us nothing about the risk of a major industrial accident on that site. There are many examples of sites that are very effective in preventing occupational accidents but which have experienced an industrial accident.

In fact, focusing on occupational safety indicators:

- can lead to the generation of occupational accident data that includes accidents linked to the operational process and others which are not, even though they do not contain the same potential risk of a major incident;
- can place the focus on minor and frequent accidents to the detriment of deeper consideration of serious and very infrequent accidents;
- can give rise to oversimplified assessments, whereas process-related accidents very often contain a whole range of technical and organizational origins;
- can lead to an underestimation of the actions needed concerning the design of facilities and organizational issues (placing greater emphasis on the "behaviour" of individuals).

Conversely, initiatives to prevent major accidents are likely to benefit from a broad consensus, and can provide the impetus for further reflection on occupational safety.

What is the human and organizational factors approach to industrial safety?

encouraging a positive contribution from operators and groups with regards to safety

The Human and Organizational Factors Approach to Industrial Safety (HOFS) consists of identifying and putting in place conditions which encourage a positive contribution from operators (individually and in a team) with regards to industrial safety.

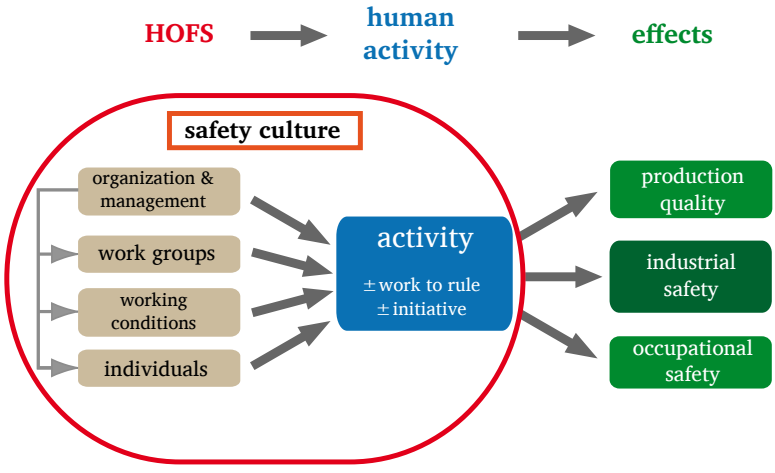

Figure 1 – *The scope of HOFS*

The knowledge offered by the HOFS approach makes it possible better to understand what conditions human activity and to act on the design of occupational situations and the organization, in the aim of creating the conditions for safe work. Efforts made in this area can also lead to an improvement in results in terms of the quality of production or occupational safety (incidence and seriousness rates).

Why adopt a human and organizational factors approach to safety?

The prevention of process-related accidents firstly focused on technical design: improved engineering has made it possible better to maintain facilities in unusual situations.

The accidents at Seveso (1976) and Three Mile Island (1979) led to the reinforcement of regulatory requirements (Seveso 1 directive in 1982 in Europe), and the implementation of general safety policies in large high-risk companies. This formal framework was further reinforced by the Seveso 2 directive (1996) and the implementation of Safety Management Systems.

These technical and organizational actions have, in certain sectors, led to a continual reduction in process-related accidents. However, in many companies, this improvement has reached a plateau and the strengthening of formal procedures is no longer resulting in a reduction in failures.

improvements have reached a plateau

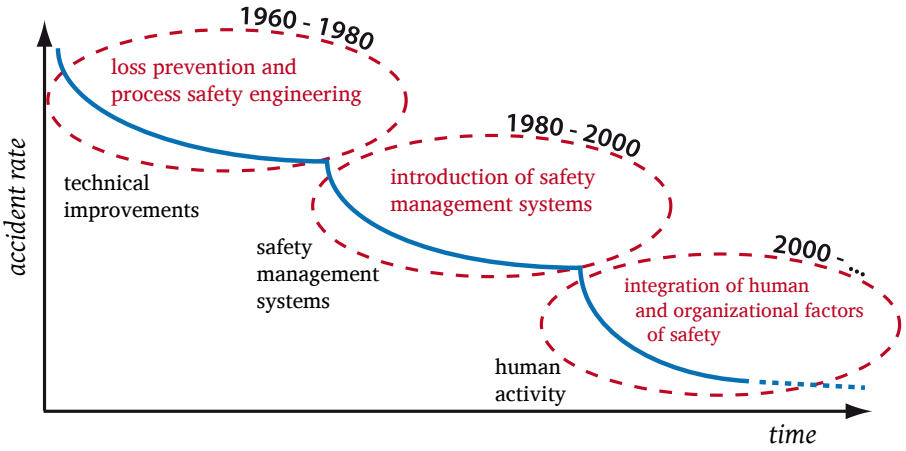

Figure 2 – *Successive approaches to industrial safety*

This limit to results which may be obtained through formal structures such as SMS can be explained by the **imbalance** between:

- ▷ disproportionate attention shown to top-down formal structures, whose role is to set out safe operating procedures;
- ▷ a search for responsibility weighted towards the behaviour of operators and a lesser importance placed on questioning the contribution of organizational and management issues;
- ▷ inadequate attention paid to the reality of the situations that operators really encounter[2]:
  - what is the acceptable quantity of written regulations for operators?
  - to what extent have the operators understood the rules and the reasons for their existence?
  - what difficulties do they have in respecting the rules? What additional human costs do these generate?
  - what adjustments would make the situation work better?
  - what relation is there between the written rules and the occupational rules?
  - what contradictions exist between the various rules or with other production requirements or characteristics of the working environment?
  - in what situations are the rules not applicable?
  - what initiatives are encouraged or impeded by the rules?
  - what opportunities are there to discuss the contradictions between different rules?
  - what is the role of management in the work on shaping the rules?

more formal measures does not always mean more safety

[2] Operation = production + management of materials and flows + maintenance
Operator = any worker, employee, technician, supervisor or manager with a role to play in the processes in question.
For the sake of convenience, the masculine pronoun (he/his) is used throughout the text to designate any operator or manager, whether male or female.

Anticipating the foreseeable and managing the unexpected

procedures do not prepare for the unexpected

Procedures and rules prepare the system for configurations that have been anticipated, and play a major role in the ability to manage these situations. But in real life, situations arise that are unforeseen. The way the system responds to these will depend on the local resources of the teams and the management available in real time.

The **resilience** of a system lies in its "capacity to anticipate, offer early detection and respond appropriately to variations in the working of a system in relation to reference conditions, with the aim of minimizing their effects on the dynamic stability". Work on system safety has shown that this resilience depends on two factors:

- **rule-based safety**: avoid all foreseeable failures through formal procedures, rules, automated safety mechanisms, the use of protective measures and equipment, training in "safe behaviour" with management ensuring that rules are respected;
- **managed safety**: capacity to anticipate, to recognize and to respond to failures that were not foreseen by the organization. It relies on **human expertise**, the quality of initiatives, the way groups and organizations operate, and on **management** that is attentive to the reality of situations and encourages coordination between the different types of knowledge that are useful for safety.

Figure 3 – *The components of safety*

Disproportionate attention paid to formalizing the response to foreseeable situations does not guarantee the relevance of the response to unforeseen situations. Worse still, organizations that base their entire safety policy on prescriptive formal procedures can find their resilience brought into question when a new or unforeseen situation arises.

compliance *vs.* initiative-taking

Compliance behaviour is not the only operating behaviour that contributes to safety: there is also **initiative-taking behaviour**, which encourages careful exploration of the state of the system, raising the alert about dangerous situations and collaboration between individuals that can contribute to safety. This is all obviously part of a general framework of technical and organizational means which encourage this behaviour to a greater or lesser extent.

The aim of this document is to help companies develop the "managed safety" aspect based on the **skills of individuals** and the way **work groups** and **organizations** operate and to harmonize it with "regulated safety" within an integrated safety culture.

The HOFS approach already exists within companies!

Naturally, companies already take human and organizational factors into consideration: the implementation of the SMS, the daily actions of the management team, supervisors, employee representatives, occupational health and safety professionals, human resources management, the work of designers, training programmes, debates and discussions within occupational groups, *etc.*

The aim of this document is to:

- clarify the links between human and organizational factors on the one hand and safety on the other;
- allow the various people involved to identify the contradictions that exist between the safety policy and other decisions that affect employees and the organization, both internally and with respect to subcontractors;

- to help them develop a safety culture that combines "rule-based safety" and "managed safety" on a daily basis.

A common reference framework in terms of the human and organizational factors in safety can facilitate collaboration between all those who contribute to safety and encourage social dialogue on this subject.

Outline

- A **summary of the key points** of the document is given in the following pages. It provides an overview of the Human and organizational factors approach to industrial safety. The concepts presented in the summary are described in more detail in the following chapters.
- **Chapter 1** describes the historical evolution of ideas concerning industrial safety, and introduced the notion of resilience.
- **Chapters 2 to 8** describe how human activity is influenced by characteristics of the work situation, by intrinsic properties of humans, and by groupal characteristics. The human error viewpoint is discussed.
- **Chapters 9 to 11** describe the organizational dimensions of safety culture.

The creation of this document

Chapters 1 to 8 and 11 were written (in French) by François Daniellou with Bernard Dugué (Ergonomics department, Institut de Cognitique, Bordeaux) with Jérôme Grall (Ergonova, Toulouse). **Chapter 9** was written by François Daniellou and Ivan Boissières (ICSI). **Chapter 10** was written by Marcel Simard (University of Montreal). Ivan Boissières coordinated the authors. The illustrations were created by Jérôme Gabet (Multimedia department, University of Bordeaux). The document was translated from French to English by Natasha Dupuy, Emma Cypher-Dournes and Eric Marsden. Draft versions of this document were reviewed by researchers, by ICSI staff and by members of ICSI's discussion group on Human factors.

Many thanks to all the reviewers who helped improve this document:

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Several managers, ergonomics experts, psychologists, sociologists and reliability engineers from EDF R&D's Industrial Risk Management department also reviewed and commented on this document.

Human and Organizational Factors in Industrial Safety: an examination of work and its contribution to system dependability

This chapter presents a concise overview of the key benefits of a Human and Organizational Factors approach to safety (HOFS). Each point is developed in detail in one of the chapters of this guide.

To understand what conditions human activity, we will first discuss the characteristics of the human being, then the impact of the working environment, work groups, the organization and more generally, the safety culture of the site.

Immutable characteristics of humans

The characteristics of the human body and human behaviour have been described by a number of scientific disciplines (physiology, psychology, *etc.*).

The way human groups operate also obeys laws which have been studied by other disciplines (sociology, anthropology, social psychology, *etc.*).

We can describe these individual and collective characteristics in order to include them in the design of technical and organizational systems that facilitate human activity.

Physiological conditions vary

The human brain is not in the same biological state at 3 AM and 3 PM. Fatigue requires it to draw on more resources (muscular, for example) to obtain the same result.

Adapting the working environment to the human being

The design of screen layouts can take into account knowledge about visual perception, human reasoning and group collaboration.

However, except for certain areas, **these characteristics are mostly immutable**; it is only possible to bring about limited changes, through training.

Some human characteristics are not modifiable

No procedure or training course will allow a night worker's brain to operate in its daytime state.

Of course, the use that will be made of these characteristics is itself influenced by a number of factors: characteristics of the working environment, the person's background, the way work groups operate, the company culture, *etc.*

Technical and organizational systems can be designed in a manner which is more or less compatible with the characteristics of humans, and either facilitates or hinders effective performance.

When we place human beings in situations that are not compatible with their individual and collective characteristics:

- we reduce their detection capabilities and the effectiveness of their actions;
- we increase the probability of uncorrected errors;
- we can generate a health risk.

Just common sense?

As human beings, we may think that we know what is good or bad in terms of human characteristics. However, common sense does not allow us to answer questions such as:

- For how long can an operator remain vigilant in front of a screen where not much is happening?
- How can we design screen layouts that make it easier to detect when a reading is deviating from the norm?
- Why do operators on a dangerous site "deliberately" take risks?
- How can the entire team have made a poor diagnosis?

These questions are as difficult to determine as the conditions for runaway of a chemical reaction or the resistance of a material.

A whole range of scientific disciplines shed light on individual and collective characteristics of human behaviour. Accident prevention requires that the knowledge produced by these disciplines be communicated throughout the company, considered with the same attention as that of scientific knowledge concerning materials and physical phenomena, and that the subsequent recommendations be included in design and reorganization processes.

Situations create behaviour

Context influences behaviour

If a lift gets stuck for an hour, the probability of panic or aggressive behaviour by the people inside increases.

Switching around the brake and accelerator pedals on an industrial vehicle considerably increases the probability of error.

Poor lighting increases the probability that an maintenance worker who has to work on a valve will choose the wrong valve or hold his torch between his teeth and risk contaminating himself.

We often hear: "We have to change people's behaviour". However, behaviour is not only the result of an operator's personality or training. The **characteristics of the situations** in which a human being is placed make certain types of behaviour more likely.

Some operating situations can have characteristics that increase the probability of undesirable human behaviour.

Human behaviour cannot be anticipated mechanically, because different individuals can behave differently in the same situation. But it is predictable in terms of probabilities: some situations tend to favour certain types of behaviour. If these types of behaviour are not desirable from a safety perspective, the only way significantly to reduce their probability of occurring is to **alter the characteristics of the situation**.

These characteristics can be local (*design of a workstation, tools, a procedure*) or much broader in scope (*company purchasing policy, disciplinary policy, training programmes*).

Work never consists of simply executing a task

Companies establish procedures, defining objectives to be reached and the steps to follow to achieve them. But the work of operators is never limited to the simple execution of procedures. **When they do operate like this, it means they work-to-rule and as a result the system becomes stuck.**

Operating situations are richly varied

Some raw materials are sensitive to humidity, this valve sticks and is harder than its supposedly similar neighbour, that pump has broken down, this operation sometimes occurs at night and sometimes during the day, sometimes when it's hot, other times when it's cold, sometimes our co-worker is tall, sometimes he is short, we may be under pressure time-wise, etc.

Operators, thanks to their experience and abilities, will recognize these variations and try to adapt their way of working accordingly. Sometimes they will detect that the situation is very far from normal and will seek help from their co-workers or their managers. Production

occurs only because each person **manages many sources of variation while executing his tasks**, with expertise acquired through experience.

Operators must also manage their own condition and its variation

Operators use a variety of strategies to stay awake at 3 AM.

During an intervention on a landing stage, the oldest and most experienced operator will climb up directly with the right tools and only the right tools. His younger colleague might have to make a number of trips because he has less experience but is in better physical shape.

By adapting their ways of working, operators attempt to carry out their tasks in a way that:

- ▷ is effective (in terms of quantity of production, quality, safety);
- ▷ does not have a negative effect on the body (tiredness, aches and pains);
- ▷ brings them a number of benefits (feeling of work well done, recognition from peers, from superiors, development of new skills, *etc.*).

achieve performance with an acceptable human cost

An operator's way of working therefore seeks to achieve **performance at an acceptable human cost**. Working methods that substantially increase the cost to operators will not be retained by them in the long run unless they are proven to be the best compromise between performance and human cost in a given situation.

An operating situation where performance is good but has been obtained at too high a human cost for the operators is a source of risks: a small alteration in the context or a change of operator would likely be sufficient to damage performance.

A "Human Factors" approach to safety implies simultaneously taking into account performance expectations and an understanding of the human costs required to achieve them.

Humans, unreliable sources of reliability

Human error is often invoked as a factor that caused or contributed to an accident. Yet often errors are the consequence of the characteristics of the situation, which have not allowed operators or groups to use their skills in a relevant way.

Overall, the human contribution to safety is primarily positive.

- ▷ Operators detect and manage a number of high-risk situations which would not have been detected or correctly dealt with by an automated device.

Human contribution to safety is primarily positive

Automated devices cannot replace humans...

A driver will wait before reversing because he sees a pedestrian about to walk behind the car. The driver interprets the intention of the pedestrian, whereas a radar would only be able to detect his actual presence.

- ▷ Human activity corrects many errors, either individually or collectively.
- ▷ Human beings learn from experience, and develop their individual and collective ability to cope with similar situations.

It is essential to understand how this contributes to dependability if we are to analyze the situations where it fails to contribute. Declaring "human error" to be at the origin of an accident is a shortcut that does not encourage prevention:

hindsight bias

- ▷ Experts who determine whether an error has been made are not in the same situation as the person who made it: they know what happened next and have other information at their disposal than that which led to the erroneous choice!
- ▷ The error led to an accident only because, on this particular day, the error was not corrected. The same erroneous action may have occurred a number of times previously without serious consequences if the technical and organization barriers were working properly. The fact that the accident occurred demonstrates a failure of the set of barriers.
- ▷ Operator error can only cause an accident if it is combined with a number of other technical and organizational factors, some of which are permanent. Design errors should be

thought of as "latent errors", *i.e.* configurations where it is highly likely that an operational error will occur one day.

Latent errors: a time bomb

If a software program in France uses the American date format, it is highly likely that someone will interpret 12/03/2008 as 12th March and not as 3rd December. If this date were included in a message such as "work underway, access forbidden until 12/03/2008", the consequences could be serious.

- The characteristics of human beings and human activity which allow us to contribute to safety, are the same ones which occasionally lead us to threaten safety.

Violations are deliberate

During roadwork, we sometimes have no choice but to cross the solid white line, which has not been erased. This is a "violation".

An *error* is always unintentional and should be distinguished from a *violation*, which is deliberate (but not necessarily reprehensible).

The use of the word "fault" can introduce a moral or legal perspective which often obscures the understanding of what happened and contributes little to prevention.

A disciplinary policy that penalizes errors and violations without taking into consideration the operator's intent and the circumstances in which he found himself, is counter-productive from a safety point of view.

The contribution of groups

occupational groups can improve safety

Occupational groups (a team of shift workers in a control room, a maintenance team, *etc.*) can make a significant contribution to safety:

- they form a barrier with respect to errors which might be made by one of the team members (detection and correction);
- the support they provide each other limits the possible safety impact of altered states in individuals (events in one's private life), and their assistance makes it possible to reduce the human cost of the tasks to be carried out;
- they contribute to the discussion of doubts about situations encountered, to the capitalization of experience in the form of "occupational rules", and can flag up abnormal situations;
- they contribute to the recognition of "work well done";
- they play a role in welcoming and training new employees, to whom they transmit knowledge that is different from that taught formally by the company (physical knowledge of the facilities, professional rules for managing certain situations).

However, occupational groups do not always play this positive role. Three types of situations are extremely negative for safety:

- Overly strong occupational groups which are perceived by the organization as a threat, and which may lead to situations which prevent dialogue concerning gaps between the company's formal rules and the occupational rules for which the group is the vector. Such situations lead to a chasm between safety as seen by the occupation and safety as seen by management, which can lead to serious risks and hinders all progress.
- Occupational groups that have been damaged, or even destroyed, by organizational changes: individuality has taken precedence over the sharing of doubts and abilities. Mutual suspicion limits the exchange of information and alerts concerning abnormal situations. The overall vigilance of the group is affected. Mutual aid no longer exists and achieving performance becomes costly for each member of the group.
- Groups that have had problems in understanding each other enter into conflict and may even oppose one another: the communication problems between professional groups will therefore increase and generate safety issues.

A human and organizational factors approach to safety requires that attention be paid to the state of occupational groups and that there is room for discussion of the occupational rules and the formal procedures of the company.

The contribution of the organization and management

The company must produce "outputs" that are acceptable for a number of stakeholders:

- shareholders;
- customers;
- regulatory bodies and the authorities;
- employees and their representatives;
- external contractors;
- local residents, maybe even the general public;
- and others.

Indeed, the ISO 9000 version 2000 standard explicitly mentions this wide variety of "clients" whose "needs" must be taken into account by the company.

Each of these stakeholders has a variety of expectations. Consequently, the challenge for the company is to bring together various rationales that are not spontaneously compatible. The **organization** is the process through which this harmonization between different rationales is achieved. The organization is both a structure (an organization chart, a set of rules) and a group of activities and interactions between people making it possible to manage the application of rules in ordinary situations or to manage changes to these rules.

Within the organizational structure, some people are more specifically responsible for ensuring the application of one of these rationales: for example, the quality, safety or environment managers. Conversely, the management team on the one hand and the operators on the other must assimilate all of these rationales, through reasonable compromises that are acceptable to all stakeholders.

At certain moments, one rationale—that of the shareholders for example—may take precedence over the others in management decisions. The safety rationale may be considered a lower priority for a while. The people who have to defend this rationale are then shown less recognition and their warnings are less heeded.

Another risk is that the safety rationale be present in form only: the rules are written and published, but the difficulties in implementing them are not dealt with. Middle management is active in ensuring rule compliance, but is not collectively involved in dealing with real, complex situations or in reporting information upwards that is likely to influence company policy.

When the organizational structure is talkative but deaf, safety is jeopardized.

talkative but deaf organization = threat to safety

On the contrary, a firm's organization contributes to industrial safety when it facilitates a continual two-way interaction between the formal rules, which provide general expertise, and the knowledge of specific operating situations, which is held by the operators and the occupational groups. Thus managers at all levels have a clear mission to ensure two-way compatibility, between the overall objectives of the company and the occupational reality of those they manage. This is one of the essential ingredients in a safety culture.

Change the culture?

"We have to develop a safety culture!" This expression is often used with the assumption that the company and the management team possess this culture and that the challenge is to have frontline workers acquire it. Communication campaigns and training programmes are sometimes put in place with this as their goal.

However, a culture is not determined by messages or rules, but rather by the **collective experience of repeated and convergent practices**.

culture: collective experience

Culture is generated through the collective experience of practices

Each time the site director has been confronted with a contradiction between safety and production, he has chosen to favour safety, or on the contrary, he has accepted to "adapt" safety rules to achieve a production target.

Each time an operator reaches a production target but has taken a risk to do so, the management team will ask him not to do it again, or on the contrary may hold him up as a hero.

Managerial messages about quality also discuss safety issues, and those about safety talk of quality or, on the contrary, contradictory priorities abound.

Each time a formal rule is inapplicable, management holds a discussion to adjust the rule to the reality or, on the contrary, they demonstrate "that they don't want to know" ...

An organization's safety culture only changes slowly

Safety culture thus relies above all on the personal commitment of members of the management team to promote the **coherence of messages and practices**, ensuring that what is done by management is in line with that which is asked of operators. Bearers of bad news or whistleblowers are welcome, particularly union representatives or subcontractors. Operational Experience Feedback (OEF) is gathered about situations where performance is achieved at a high human cost to ensure they are not repeated. When an operator or an occupational group signals the fact that an error has been made, this is welcomed positively. Subcontractors are considered as partners with regards to safety matters. Responsibilities are shared. The disciplinary system is explicit and considered as legitimate by all. Contradictions between formal rules and occupational rules are debated, as are innovative ideas. The design process takes into account the reality of work situations. Management of human resources encourages knowledge transfer within the occupational groups.

A safety culture results in the shared awareness that **each individual only has access to part of the information and knowledge needed to ensure safety**. Fundamentally, it is a culture of discussion, of confrontation and of integration of a variety of rationales. Therefore, it cannot be achieved simply by respecting the occupational health and safety laws, site occupational health and safety committees and trade union prerogatives but rather requires a style of social dialogue and relations with subcontractors that encourage the ongoing development of each stakeholder's contribution to accident prevention. Furthermore, when this culture develops, it contributes not only to safety but also to production quality.

A safety culture requires a two-way interaction between the central levels of the company, which define the general objectives and the collective rules, and the sites and unit levels which are exposed to operational realities, handled by company employees and subcontractors. The group provides a framework for the sites and the units, and is enriched by feedback on the difficulties in implementing the rules, the tradeoffs and local compromises that take place between bearers of different rationales. The principle of experience feedback also applies to senior management and head office experts.

Integrating HOF into the SMS

Integrating human and organizational factors into a company's Safety Management System does not mean creating a new section in the existing document.

It means considering safety as the result of everyone's work: design work, organizational work, operating work, audit and monitoring work. Many people from all levels of the company and from the pool of subcontractors are bearers of information and expertise that are vital for safety. Safety partially stems from the preparation of responses to foreseeable phenomena, thanks to expertise shared on an international scale. Another element is based on the individual and collective human ability locally to manage situations that had not been foreseen. The HOF approach encourages strengthening awareness of the need for these two aspects, understanding that their compatibility is never guaranteed and taking the measures needed to encourage it. It requires everyone in the field of safety to recognize that their knowledge must be combined with that of others, who have different knowledge to their own.

Assimilating the human and organizational factors of safety remains a question of commitment from individuals at all levels of the company. The organizational structure can either make this commitment difficult, or on the contrary support it.

1

Manufacturing safety

*Safety is a **dynamic non-event**, where success is measured by the **absence** of unacceptable outcomes*

Where industrial safety is concerned, what we are aiming for is an *absence*. The objective is to prevent events with unacceptable potential consequences from occurring. However, this absence can never be considered to be definitively acquired. Safety is "a dynamic non-event". A system only acquires a degree of safety through the initial work of those who designed it and the daily work of the many people who seek to prevent undesirable events, limit their consequences and draw lessons from them. In the same way that the system undergoes internal and external developments over time, safety also requires a periodic reassessment of previously held assumptions and possibly adaptation.

However, the people who contribute to this production of safety do not have only that aspect to manage: most must also contribute to ensuring levels of productivity and production quality that are satisfactory for clients and shareholders. A human and organizational factors approach to safety consists of considering this safety production work as one of the aspects of general production, supporting those who encourage it and dealing with contradictions that may hinder it. In particular, this chapter will introduce the idea of the *resilience* of an organization.

1.1 Acceptable risk

The industries that we are discussing here are confronted with *hazards*: runaway reactions, the kinetic energy of a train, high-voltage electricity, *etc.* These hazards generate *risks*, in other words, the possibility of damage to people, the environment or goods[1].

Industrial safety involves anticipating and preventing events whose effects could be particularly serious, even if their probability of occurrence appears to be low.

The acceptable level of risk in a given time and place is determined by society. As an example, in France each year there are around 1 100 murders and 7 500 deaths from work-acquired cancers. Society considers the former to be much more unacceptable than the latter. Societies in industrialized countries demand a much lower level of risk for the general population from their industries than they accept for example, from their healthcare system (or their fairgrounds!). As industrial accidents have occurred, the authorities have put in place strict regulations. These obviously contribute to safety, but they alone cannot guarantee it.

1.2 A change in opinion

Public opinion, regulations, but also scientific approaches to industrial risk have been affected by a series of major accidents and by the lessons that have been drawn from them. Table 1.1 below lists some of these major events and their consequences, and underlines some aspects of the human and organizational factors of safety which have been highlighted by their subsequent analysis.

[1] We should emphasize that being able to identify a risk does not imply that we know how to calculate the probability of it occurring, which is indeed only known precisely for frequent events. Serious accidents are events where the probability calculated probably was—or would have been—very low.

[2] Human-Computer Interface

Date	Site	Country	Activity	Incident	Consequences	Some HOF issues
1976	Seveso	Italy	Chemical plant	Dioxin cloud	Environmental disaster, 70 000 head of cattle slaughtered	Seveso Directive (EU)
1979	Three Mile Island	USA	Nuclear power plant	Primary leak	Partial core meltdown	Complexity of systems, Human–Computer Interface², control room, procedures, tunnel vision and the way organizational redundancy is structured
1984	Bhopal	India	Pesticide factory	Explosion	Over 16 000 dead	Maintenance, urban planning, technology transfer, disregard of whistleblowers
1986	Challenger space shuttle	USA	Space programme	Breach in a joint	Disintegration on liftoff, 7 astronauts killed	Organizational causes, effects of the organization's previous history
1986	Chernobyl	USSR	Nuclear power plant	Reactor explosion	Radioactive leak, ≈ 50 000 dead, millions of people impacted	Production pressure, monitoring, appearance of the safety culture notion
1987	Herald of Free Entreprise	North Sea	Ferry	Capsize	193 killed	Production pressure, procedures, whistleblowers
1988	Gare de Lyon	France	Railway	Collision	56 killed	A number of design and organizational factors
1992	Mont Saint-Odile	France	Commercial airline	Crash	87 killed	Strengthening of human factors in design
1998	Longford	Australia	Gas plant	Explosion	2 killed, 8 injured, state gas supply interrupted	Limits of a safety culture focused on minor accidents
2001	Toulouse	France	Chemical fertilizer plant	Explosion	30 killed, 2 500 injured, urban destruction	Creation of the ICSI
2003	Columbia space shuttle	USA	Space programme	Damage to the thermal protection system	Destruction of the shuttle as it re-entered the atmosphere, 7 killed	Organizational causes of the Challenger disaster were not addressed
2005	Texas City	USA	Refinery	Explosion	15 killed, 170 injured	Very low incident rate is not a guarantee of process safety

Table 1.1 – *A selection of major industrial accidents and some HOFS issues*

The development of scientific work on the risk of industrial accidents and their prevention has been impacted by these events. Although we cannot make a direct link between these events and the emergence of theories, we can highlight (*cf.* table 1.2) a number of publications that have contributed to developing the HOFS approach. This list is not exhaustive; many other references will be mentioned in each chapter of this guide.

This research has notably shed light on the two major contributions to industrial safety: anticipation of what it is possible to foresee and the ability to react when faced with the unforeseen.

1.3 Anticipatory work and daily work

When a system is designed, the hazards are identified and the risks are assessed. Designers seek to identify the operating configurations that lead to a risk. The prevention of these identified risks is ensured by a series of barriers:

- the technical design of the system (inherent safety, layout, separation distances, automated safety devices, *etc.*);
- the definition of operating and maintenance procedures that aim to keep the system within safe limits;
- training operators to follow procedures;
- the setting up of an organizational and management structure that ensures rules are respected;
- regular audits to ensure the system is run as planned.

1947	Fitts and Jones	Errors of military pilots that led to crashes can be explained by the cockpit design
1968	Leplat and Cuny	Research on remote control
1970	Faverge	Man as a source of reliability and unreliability in complex systems
1970	INRS, Cuny	L'arbre des causes
1974	Edwards and Lees	The Human Operator in process control
1979	Weick	The social psychology of organizing
1981	Rasmussen	Human detection and diagnosis of system failures
1982	[Seveso Directive]	
1984	Perrow	Normal Accidents: Living with high-risk technologies
1985	Leplat	Erreur humaine, fiabilité humaine dans l'entreprise
1986	Beck	Risk society
1986	Daniellou	L'opérateur, la vanne, l'écran, l'ergonomie des salles de contrôle
1987	Roberts, La Porte, Todd	First conference on High Reliability Organizations
1989	De Keyser	Summary article on «human error» in *La Recherche*
1990	Reason	Human error
1990	Leplat, De Terssac	Les facteurs humains de la fiabilité dans les systèmes complexes
1996	[Seveso 2 Directive]	
1996	Amalberti	La conduite de systèmes à risques (notamment la gestion des ressources cognitives)
1996	Vaughan	The Challenger Launch decision
1996	Llory	Accidents industriels: le coût du silence
1997–2000	Simard	Safety culture and its management
1999	Châteauraynaud, Torny	Whistleblowers
1999	Bourrier	Le nucléaire à l'épreuve de l'organisation
2001	Weick	Managing the unexpected
2004	Hollnagel	Barriers and accident prevention
2006	Hollnagel, Woods, Leveson	Resilience engineering

Table 1.2 – *Some publications on the HOFS approach.*

The assumption is that if the rules are followed, there is a very low probability that the undesirable operating configurations that have been identified will occur. And yet, even during the initial nominal operation of the facilities, a number of unforeseen events occur, for which the procedures do not provide all the answers, and which are managed by production and maintenance operators with or without the interaction of management. Two main reasons explain this difference between the reality and the forecasts.

On the one hand the system contains many more subtle variabilities than can be foreseen at the design stage.

System variability

Two identical valves have slightly different reactions, a bolt is stuck, a viper has made a nest in an electric cabinet, a ladder has been used elsewhere, etc.

Operators in the field detect these variations and adapt their ways of working. Sometime safety means sacrificing production: we trigger an emergency shutdown; we call a halt to an operation. But if production is stopped every time nonconformity arises, the effectiveness of the system will be weakened, to say the least[3]. A great many adjustments are made all the time, to deal with situa-

[3] This is the principle of rail safety (for passengers): a train can only return to a "block" if the conditions within it are in conformity. If this is not the case, the train must wait at a signal or cross it slowly once given authorization to proceed. The "whilst it's not clear, we wait" principle ensures a high level of safety but generates delays, which in turn contribute to the current questioning of the system's productivity. On the other hand, the safety of employees working on the tracks is not based on this principle of all or nothing. It is based, as is usual in high-risk industries, on nuanced local adjustments (obviously, within the framework of general rules) between safety and productivity (Hale and Heijer, in Hollnagel et al., 2006).

tions that are not covered by a procedure. And those carrying them out consider that they are done in a way which is compatible with safety.

Moreover, events that have each been foreseen individually in a procedure may become combined, or anticipated events may become combined with unanticipated events. It is neither practically nor conceptually possible to imagine a meta-procedure that would cover all possible combinations. Operators that are present will decide on an original response to the unusual situation by drawing on their individual and collective resources and, perhaps, by consulting their superiors.

the same measures can lead to success or to an undesirable event

In the vast majority of cases, these unofficial adjustments of procedure ensure both the safety and productivity of the system. Much more rarely, they are identified post-event as being one of the factors of an incident or an accident. Often, the transgression that caused an accident will be reported or analyzed but not the bending of the rules that resulted in success. Yet, industrial safety considerations must take into account that it is the same mechanisms that ensure the daily success of the production and the undesired event.

Whilst adjustments like those that have just been described are needed from the start of the nominal operation of a system, they tend to become more significant as the system ages.

1.4 System migrations

The system is initially designed for certain operating conditions. Over time, the system evolves and its operating conditions change. This is the major challenge facing industrial safety.

The system in itself evolves over time. Some components age or erode, their obsolescence makes them difficult to maintain. Local modifications are made, without the entire risk assessment being repeated. Employee populations change: for example the older, more experienced employees are replaced by young people who are more qualified but who have much less knowledge of the facilities.

the system and its operating conditions evolve

All the while, operating conditions are changing as well. New products are requested by customers. Productivity demands increase and short-term local objectives are sometimes contradictory to the long-term security demands. Organizations are modified. Additional layers of procedures are added to those that were initially defined. Formal procedures relating to quality and safety have been strengthened, proportionally reducing the time available for actually carrying out production or maintenance operations.

The system thus migrates into an operating area different from that which was the subject of the initial risk assessment. It may tend to push the limits of safe operation: **virtual limits that everyone knows exist**, but which can only be precisely identified once they have been transgressed.

For all this, in the daily life of the system, everything continues to work as normal. Production continues and no major incident has occurred. Unofficial adjustments become more frequent, to ensure that quantity and quality remain within the required boundaries. As there has not been a serious incident in a long while, the system may be considered to be as safe as during its initial nominal operation, and safety can become routine. All management indicators are green, possibly including the incident rate of accidents involving people. Nothing seems to suggest that this facility will soon be making headlines in the papers.

Nothing? Of course this is not true. Production and maintenance operations have become more difficult to carry out: the end result is still good, but the operation generated more difficulties for the people carrying them out, took more time, and required more attempts.

the weak signals of system migration

More and more procedures are breached more consistently without this being cause for discussion. Situations where production would previously have been halted are now tolerated. The gap has widened between the top-down managerial message and the reality of what operating employees are experiencing. Some are very unhappy as they have the impression that things are very close to the limit, but they are unable to express this, except sometimes to the occupational physician. Some voices may be heard, for example at the occupational health and safety committee, but these are interpreted as being just another example of the age-old struggle between management and workers.

This scenario is obviously not the only one that is possible. The concept of "resilience", which has developed widely in recent years, describes the capacity of an organization to actively manage variations in operating conditions rather than to be blindly led towards the fatal limit.

1.5 Resilience

In materials science, *resilience* is the word used to describe the capacity of a material to resist an impact. In psychology, it is the capacity of someone to live and develop after having experienced a traumatic shock or a serious incident.

In the field of safety, by analogy, *resilience* first designated "the capacity of an organization to regain a dynamic state that allows it to develop again, after a major incident". In other words, if the system is resilient, its capacity to thrive is not destroyed by the incident.

This understanding of the word resilience is too restrictive, in the sense that it only qualifies the capacity of the organization to cope once the event has occurred. Yet, clearly, this post-event capacity starts before the event, in the manner in which the organization is able to anticipate the event, prepare the adequate response, detect the signals that show it is impending and manage it should it occur. We can therefore consider that: The resilience of an organization is its "capacity to anticipate, offer early detection and respond appropriately to variations in the working of a system in relation to reference conditions, with the aim of minimizing their effects on the dynamic stability[4]".

anticipating, detecting and coping with disruptions

To develop its resilience, an organization must:

- be aware that the safety level at a given time is always threatened by evolutions and migrations of the system, particularly the contradictions between long-term safety objectives and short-term productivity objectives;
- be aware that the clues indicating that something is drifting to the limits of the safe area do no necessarily show up in the usual management indicators. Many of them are known to the people in the field, but the information is not passed on spontaneously by the existing information systems;
- encourage both the reporting and discussion of warnings;
- recognize the need to take into account the knowledge of experts and knowledge in the field if we are to define rules that are compatible with evolutions in the system in terms of safety. Each individual is only privy to some of the necessary knowledge;
- explicitly recognize the site-based management and the occupation health and safety personnel as key players in this process of detection and dealing with variations in operation.

We will examine all these points in detail. In the next chapters, we will firstly describe the contribution of **individual activity** in the adjustments that allow the system to operate safely, but which may also threaten its safety. The strengths and weaknesses of the characteristics of the human being have to be taken in account when considering safety. We will then highlight the role of **groups** and **organizations**.

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[4] In [Hollnagel et al. 2006].

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2

From "behaviour" to activity

In this chapter we are going to examine the link between individual activity and industrial safety. Reference to people's "behaviour" is often included in safety approaches. This term can refer to an approach to human work that is more restrictive than that put forward by the Human Factors approach, which seeks to understand human activity and what plays a part in determining it.

2.1 Behaviour is what you observe

The **behaviour** of a living being is the part of his activity that can **be seen by an observer**: posture, movements, verbal or gestural expression, visible physiological changes (sweating for instance), the use of a tool or equipment, *etc.*

When we observe an animal, we can only make assumptions about what has caused the behaviour we have seen. In the case of a human being, we can go beyond the behaviour and ask ourselves about the organisation of the person's activity and what determines it. We therefore look at the cognitive[1], psychological and social aspects that are behind the observable behaviour.

Behavioural approaches

Definition

Behavioural approaches to safety, as practiced by a multinational chemical company and consultancy firms, are based on the ABC model (Antecedents, Behaviour, Consequences): behaviour is considered to be the result of certain antecedents and an anticipation of possible consequences. This model emphasizes the fact that the anticipated consequences have more influence on behaviour than the antecedent causes. Furthermore, definite, immediate and positive consequences have a greater influence on behaviour than uncertain, far away or negative consequences. Continual safety improvement programmes, based on this model, include the observation of the behaviour of operators by their co-workers or their superiors, immediate approval of behaviour considered to be positive for safety and a capitalization on observed practices. The main target of this type of method is the conformity of behaviour to instructions, such as wearing personal protective equipment and following procedures.

2.2 Compliance behaviour and initiative-taking behaviour

When some companies talk about "behaviour", they mainly mean behaviour that is **in line with prescribed rules**: wearing personal protective equipment (PPE), following procedures, and keeping one's workplace tidy. These are indeed examples of behaviour that can have a positive or negative effect on safety.

compliance behaviour

But this approach neglects a number of other types of behaviour, which demonstrate **initiatives** taken by operators in relation to prescribed rules: noting a number of informal clues about the operation of the facility, detecting when a procedure is not applicable because a piece of equipment is being worked on, reporting a risk, halting a system when its operation is doubtful, suggesting improvements, supporting co-workers and showing mutual vigilance, teaching new team members to be cautious, contributing to activities relating to prevention. All of these are major components of safety.

[1] Cognition includes the search for information, the construction of appreciations and reasoning, decision-making, the planning of actions and the monitoring of their results.

Initiative-taking behaviour contributes to safety performance

Research conducted in high-risk companies has, of course, shown that there is a positive correlation between "compliance behaviour" and the level of safety, but it also shows that there is a much higher correlation between the rate of "safety initiatives" and the overall safety results[2].

This is why it is not particularly relevant to focus a "Human and Organizational Factors in Safety" policy solely on compliance behaviour. Furthermore, behaviour is the visible aspect of a complex activity. We have to understand what influences that activity.

2.3 Activity: a person's efforts to reach goals

The *activity* of a person means the use of his body and intelligence to achieve successive goals in specific conditions. Activity includes a visible aspect (behaviour) and non-visible aspects (perceptions, emotions, memory, knowledge, reasoning, decision-making, control of movements, *etc.*). Work activity at a given moment is a response to a number of determining factors:

- the production objectives, tasks to be performed, the rules that define them, the way the person has interpreted them;
- the equipment available, the working conditions, the characteristics of the item and the materials, the environment, time constraints;
- the characteristics and the physical and psychological condition of the person;
- his abilities and knowledge, acquired through training or through experience in a variety of situations;
- his motives, his values, the other goals that he is seeking to achieve;
- the available collective resources;
- the ways in which management is present;
- the values and cultures of the groups to which the person belongs (including the safety culture of the unit), *etc.*

Through his activity, the operator seeks to achieve the set targets, but by taking into account variabilities that arise:

- variations in context, in the state of the process and the materials, the available equipment, the collective resources;
- variations in his own condition (day/night, tiredness, pain, *etc.*).

Sometimes, these various objectives are not easily compatible. Rules from different departments may be partially contradictory. An incident can include an unusual combination of events, where there may be a procedure for dealing with each event, but not for when they are combined. The operator and the work team will have to sort through the instructions and merge them to build a response which will be the best adapted to the real situation.

Experience and activity

A procedure that is closely followed by an experienced operator will not produce the same activity as the same procedure closely followed by a temporary employee.

Activity is therefore not just the simple execution of the procedure:

- in some cases, the procedure has been followed to the letter, but the activity has provided added value (verification of the environment and conditions of application, knowledge of the reactions of materials, non-compulsory intermediary checks):
- In other cases, there is a gap between the activity and the procedure. A number of reasons can explain this: the procedure is unclear; the procedure does not correspond exactly to the current situation; following the procedure results in extra work for the operator that he does not consider to be justified; his professional knowledge leads him to think of another manner of working that seems more appropriate, *etc.* **This difference in relation to the procedure cannot only be treated in terms of "nonconformity": it requires understanding of the reasons that explain it**, and potentially of the contradictions that could have existed between the various determining factors.

[2] See the study by M. Simard et al, *Processus organisationnels et psycho-sociaux favorisant la participation des travailleurs en santé et en sécurité du travail*, Institut de recherche en santé et en sécurité du travail du Québec (IRSST), 1999, http://www.irsst.qc.ca/fr/_publicationirsst_662.html.

changing behaviour means acting on situations

Behaviour observed at a given moment is the result of the complex construction of the activity. We can only change behaviour if we act on what *causes the activity to be organized in a certain manner*. If the observed behaviour is undesirable from a safety point of view, we must:

- ▷ **understand** what influences the organization of the activity;
- ▷ **change** some of the elements that influence it.

Shifting from a behaviour-based approach to an activity-based approach means giving oneself the opportunity (and taking the risk) of identifying more numerous, deeper and more complex determining factors of human behaviour that influence safety; it means altering the terms of discussions between the various parties that contribute to prevention; it means allowing new scopes of action for the design of safer technical and organizational systems.

To make this analysis and the choice of relevant preventive actions easier, the following chapters cover in detail the way in which each one of the factors can influence activity.

2.4 The hidden part of the iceberg

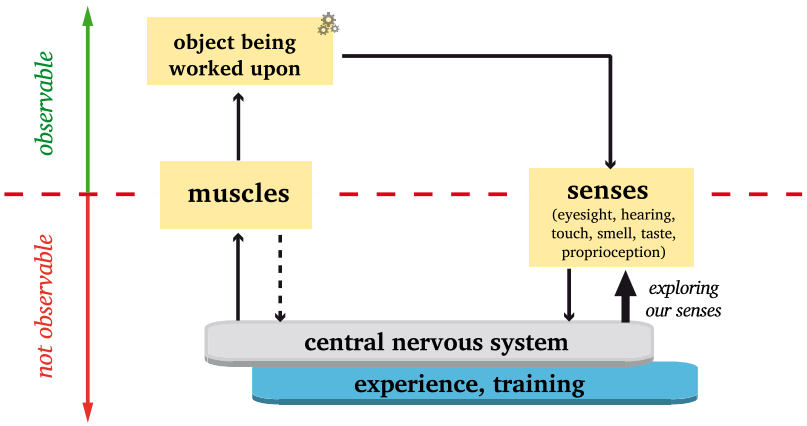

Figure 2.1 – *Hidden and visible aspects of activity*

We sometimes talk about "manual work". However, purely manual work does not exist. In any situation, the operator perceives information thanks to his senses, which are themselves guided in their exploration by the brain, whilst the central nervous system will give orders to his muscles to guide his action on the object of his work. This brain activity which constantly drives the carrying out of actions is known as "cognitive activity".

Cognitive activity is partly conscious, and partly automatic[3], with the conscious self only being alerted if something unexpected occurs.

This cognitive activity is obviously affected by the person's entire history, by all the traces that his brain has stored of what he has experienced (including his training). Experience even influences the search for information by the senses.

In Chapter 4 we will cover the main characteristics of this cognitive activity.

Automatic behaviour and conscious awareness

We walk along a pavement without being consciously aware of the action of walking. We become aware the moment we put our foot in a hole.

The influence of experience on the search for information

An inexperienced car driver will not use his eyes in the same way as an experienced driver: the former looks to the front right of his vehicle, the latter looks far ahead. The experienced driver will find himself in the position of a learner if he has to drive on the other side of the road, abroad.

A new control operator will not look for the same information at handover as an experienced colleague: the latter will first look for certain key parameters, whereas the new recruit will scan a number of screens.

[3] These are acquired automatisms and not reflexes: the latter are innate (taking one's hand away from something hot). A car or a chemical facility cannot be operated by one's reflexes.

2.5 It is difficult to talk about one's work

Everyone knows how to tie their shoe laces. And yet, it would be rather difficult to explain to someone over the phone how to tie laces, without being able to show them. This is an example of **incorporated knowledge**, knowledge that has become automatic and which is not easy to put into words.

Much of the knowledge used in the workplace is of this nature:

- it is not because an operator knows how to do something that he knows how to explain it (to his superiors, to an auditor, to a new recruit);
- the fact that he has difficulty in explaining it does not stop him from being the holder of knowledge that is potentially important for safety.

It is not always easy to explain what we know...

"The furnace is at the right temperature when it glows slightly orange and the air is slightly... it's complicated!"

There are not always words to describe everything. Yet it is possible that the operator holds working knowledge that is more refined than that provided by oxygen meters, for example. It is also possible that if this operator were replaced by a younger employee with a technical diploma but little practical experience and this knowledge is not passed on, the oven would be less well managed than before.

The ability to talk about one's work obviously also depends on the general context, on the image we have of the person asking the questions, the use that he is likely to make of the answers, the experience feedback and disciplinary policies.

Taking Human and Organizational Factors of Safety into account inevitably means encouraging the **expression of operator knowledge in the operational context**, since it brings to light other aspects of safety than those provided through the knowledge of experts.

2.6 Performance does not reflect the human cost

An operator carries out an activity to achieve objectives, whilst preserving his own state of health as much as possible (avoiding poor posture or extreme effort, for example).

- When the situation includes sufficient leeway, the operator can create a way of working that is effective and takes into account the warning signs from his body.
- In order to achieve the set objectives when this leeway is reduced, he must "suffer in silence" and find ways of working that are still effective but which cost him dearly. The costs can be physical, but also cognitive (difficult reasoning, uncertainty, making many decisions in a short time-frame, *etc.*), psychological (affecting self-esteem, *etc.*), or social (tensions with co-workers).

performance can have a human cost

- It can happen that even though the operator suffers in silence, there is no way of working that will allow him to achieve the objectives that have been fixed. This is the "saturation point".

Therefore, **performance achieved does not reflect the human cost required to achieve it**. Excellent results (from the point of view of the company's criteria) may have been obtained at a very high cost for certain operators. The fact that they have managed to do what was asked of them says nothing about the personal costs this generated. If reporting only concerned compliance between results and objectives, there would be "nothing to report". Yet this situation is loaded with risks: if the performance has been reached this time but the operators had great difficulty in achieving it, it is probable that a slight variation in the context or a change in person would lead to a non-compliant result.

A Human and Organizational Factors Approach to Safety invites us to constantly re-evaluate the carrying out of a task through the dual perspective of performance and human cost:

- Is the result good?

- ▷ What sort of difficulties did the achievement of this task generate? What were the costs to individuals and to the industrial safety of the socio-technical system?
- ▷ If the human cost of the performance is unusually high, corrective actions are needed.

Let us now examine in more detail how **the characteristics of the working environment** will influence the activity that takes place there.

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3

The working environment influences behaviour

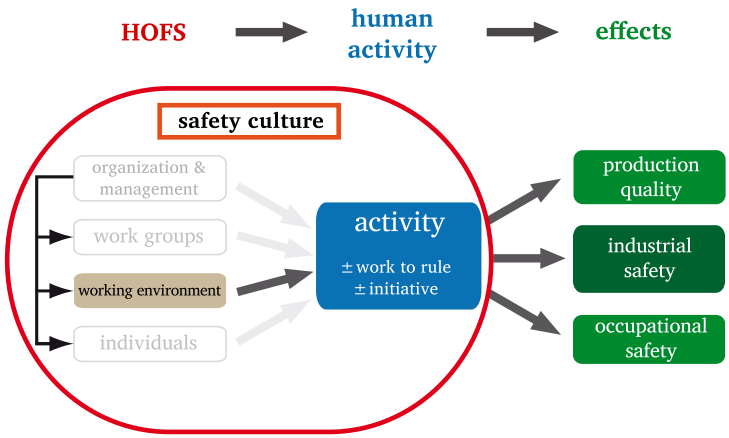

Figure 3.1 – *This chapter addresses the influence of the working environment*

The operator working on an aspect of the process is placed in a **working environment** that will play a part in determining his activity and therefore his observable behaviour. If we take a photograph of him, some of this working environment will be visible: a portion of the facilities, the tools, a co-worker, *etc.* But many more components of the workplace environment will not be visible in the photo: the company's strategy, the history of the facilities, that of the operator, the social relationships, the rules of the organization, the work groups, the time needed to carry out an operation, the temperature and the odours that emanate in this area, *etc.* These other aspects of the situation influence the operator's activity just as much as those visible in the photo: if we want to understand why the activity of operators has a particular characteristic, it is often necessary to look for reasons other than those that are immediately visible.

all the components of the working environment are not necessarily visible

Figure 3.2 summarizes a variety of components of the working environment that will influence activity.

The operator is part of the working environment. His own condition is extremely variable, as a result of biorhythms, tiredness, personal events, as we will see in more depth in chapter 4. Managing his own condition is part of his activity.

3.1 The situation is always unique

The situation that the operator has to manage is always unique. Even if the prescribed operation is habitual, certain factors are specific to this particular time: the weather conditions, the time and the day of the week, the state of the upstream or downstream facilities, the equipment to be used, a maintenance technician nearby, the team not being made up of the usual members, a change in procedure, a flywheel that is stiff, *etc.*

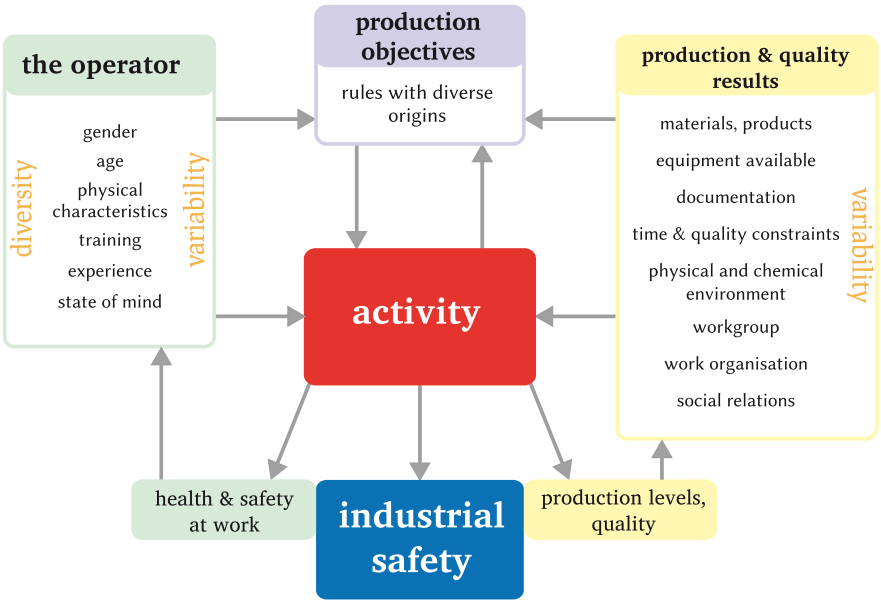

Figure 3.2 – *The components of the working environment*

In many cases, these sources of variability do not affect the operation: by making some modifications to his way of working, the operator compensates for a small variation in the context and manages to carry out the operation whilst generally respecting procedure.

addressing the variability of the situation

In other cases, the operator or the group consider that the difference is more significant and that they have to do things differently. Based on their appreciation of the situation and their experience, they will implement a way of working that they consider to be appropriate. In the vast majority of cases, this way of working will lead to a positive result, and the fact that the procedure was not followed will go unnoticed. Sometimes the adjustments that are made have detrimental consequences, because the situation included certain aspects that the operators were unaware of or did not take into account. They will therefore be reprimanded for having taken liberties with the procedure. We identified this paradox in chapter 1: it is this same deviation from the rule that ensures productivity and which can lead to accidents.

3.2 The facilities and equipment

The machines and the tools that are used on the plant have been designed by engineers who have taken into account a wealth of knowledge about physical and chemical phenomena, the resistance of materials, *etc.* But some of their properties cannot be anticipated, and will be discovered during the activity of those who make them work or maintain them.

Certain characteristics are only discovered through experience

Pumps A and B are similar but A starts cavitating much more easily than B. When all is going well, this pipe makes the sound of a torrent, while that one should make the noise of wind in the trees. We should be able to put our hand on this pump, except when it is emptying. If the ground is vibrating like that it's because there is a problem with the running of the motor. The end product should smell of ripe apples, if it smells of vinegar there is a problem. When we manufacture product X, we must not exceed two thirds of maximum output; with product Y we can go to the limit, etc.

Through their physical experience of operations, operators develop clues that allow them to rapidly and concisely identify the state of an equipment, an operation or a product. This same experience also shows them the best way to deal with these. Like a farmer who knows his cows, an operator entering a zone detects the early signs that something is abnormal and acts accordingly. When the handover to the next generation of workers goes well, these signs and rules are transmitted to the younger members during their apprenticeship.

If, for reasons of safety or efficiency, the decision is made to operate this part of the facility remotely, sensors and transmitters will be installed to send these parameters to a control center. But often the parameters reported will be those that the designers think are necessary to monitor and operate the facilities: outputs, pressures, temperatures, percentages of oxygen, *etc.*

Can we do without human experience and perception?

How can we rely on an oxygen meter to operate a furnace, when it is the operator who knows by experience how the different shades of orange colour and the changes in air movement indicate the state of the furnace? Of course, the operator can learn to use the oxygen meter, but will the operation be as nuanced and as safe? Would it not be useful to provide a camera as well?

The facilities are thus the object of a dual expertise and a dual ignorance: some of their daily characteristics are known to operators through experience and, more often than not, the experts are unaware of them, whereas certain configurations that are to be avoided are calculated by the experts and thankfully, have never been experienced by the operators. Avoiding disasters, however, cannot be achieved by ignoring the adjustments that are needed in daily life.

3.3 Instructions and rules

In the working environment, working instructions and rules come from a number of sources:

- the daily or weekly instructions given by management in terms of production targets;
- the formal rules, the procedures;
- the occupational rules, which allow a welder to assess the look of his welding, the plumber to evaluate the state of a joint; and the informal rules of work groups *(we help an older co-worker carry a heavy load, we do not interrupt a co-worker who is taking a complicated sample)*;
- the constraints that emanate from the material itself or the facilities: if the valve is stuck, it "requires" a particular operation, with specific tools, in order to be able to open it.

These different sources of instructions can sometimes be partially contradictory. Human activity does not consist in simply executing instructions: it involves responding to a range of instructions, which cannot all be respected at the same time and all the time. Working therefore means sorting and prioritizing these potentially contradictory instructions.

3.4 Distal determining factors

Some of the determining factors of the working environment are well outside of the frame of the photograph mentioned above. The price of crude oil, the history and financial state of the company, its pay and subcontracting policy, the organizational structure, the labour relations on site and local management style are also elements of the working environment.

On the one hand, these aspects influence production objectives and the way in which they will be imposed. On the other hand, they determine, more or less directly, how much latitude an operator has in obtaining a more suitable tool, indicating the part of a procedure that he considers inadequate, taking a break after a difficult manœuvre, stopping an operation that he considers dangerous, or asking for help from an experienced colleague.

If we want to understand the choices that direct the activity of an operator, and only seek to explain them by immediately visible determining factors, some of these choices will probably appear to be irrational. If, on the contrary, we pay attention to the wider determining factors over a large time scale, the reasons for these choices may become clear.

behaviour that is apparently "irrational"

Digging down to the root causes

The inquiry into the Challenger space shuttle accident highlighted the fact that information was held back by teams involved in the launch preparation. To understand this attitude, the inquiry had to look back over a number of years at the reorganizations that had placed teams in competition with one another, including in their evaluation modes.

3.5 The activity as a response that includes costs and benefits

When faced with a wide range of sources of variability and multiple partially contradictory rules, human activity provides a response: the operator makes an assessment, takes decisions, launches actions and communicates with others.

This is not the only possible response. If it has been chosen, it is because the brains of the people involved have performed a cost-benefit analysis (very quickly and, of course, mainly unconsciously). In no particular order, we can list as potential costs taken into account: fatigue, the risk of accident, length of exposure to pollution or noise or uncomfortable temperatures, disapproval of co-workers, disapproval of superiors, poor quality of work, administrative restrictions, financial losses, *etc.* Amongst potential benefits: an operation that is less difficult, the rapid achievement of an objective, the quality of the result, the demonstration of one's expertise, recognition from superiors, the admiration of co-workers, the development of new skills, financial gain, safety, respect of one's own values, *etc.*

a complex cost-benefit assessment

The weighting of these different criteria obviously depends on the person, the situation and the type of choice. Behavioural theories—which we mentioned in chapter 2—tell us that the certain, immediate and positive consequences have a greater impact on choices than uncertain, postponed and negative ones. This approach can be useful to guide certain managerial choices, but, of course, must not be used to replace an operator's choice mechanisms in a given situation.

If the operator response that results from this "cost-benefit analysis" is considered by the company to be inappropriate, this can only be changed by altering the characteristics of the situation that influenced the choices.

Bibliography

See chapter 2.

4

Human operators are different and variable

Human beings have characteristics that result from our biological makeup and which cannot be modified at will. They should be taken into account in the design of work systems, to the same extent as for the physico-chemical properties of products and processes. Otherwise the human being will adapt within certain limits, but always at a high personal cost and to the detriment of his performance.

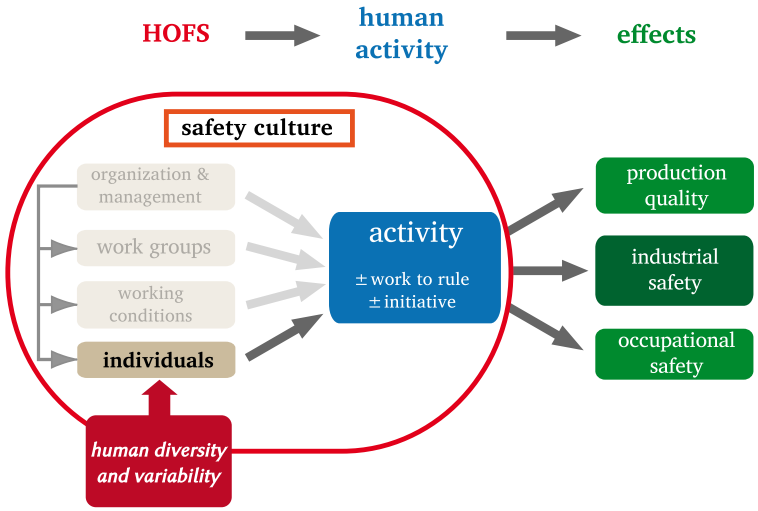

Figure 4.1 – *The subject of this chapter*

It is clearly impossible in this document to cover all the characteristics of the human being that may come into play in the workplace. This chapter presents some aspects of the diversity of individuals and how the condition of the body varies according to the time of the day or night. In the following chapter, we will present the main characteristics of the brain and human reasoning, which must be taken into account in the design phase.

4.1 We are all different

there is no such thing as an average man

Industrial facilities are operated by people with very different characteristics. If the design is based on the "average man", with no regard to these differences, this can result in difficulties for a large number of employees, and have a detrimental effect on the correct operation of the system. The main differences that should be taken into account at the design stage are listed hereafter.

Gender

Many facilities were traditionally designed for male operators. When designing facilities today, it is essential to include the possibility that female operators may work there. In particular, this means including suitable sanitary facilities and taking into account anthropometric differences.

In terms of physical strength, we should beware of clichés: the average physical strength of men is greater than that of women, but the two distributions overlap greatly and many women are physically stronger than many men! A physical effort that most women would find difficult will also be a challenge for many men.

Anthropometry

The range of human heights and sizes is considerable.

> To cover 98% of the French male population, we would need to include heights between 159 cm and 194 cm. The latest statistics show the emergence of a group of very tall young men (averaging 191 cm) which did not previously exist and which now represents 8% of the male population! To take into account the female population in the same way, the range of heights has to start at 148 cm.
>
> Furthermore, the length of various body segments is not proportional to a person's height.

This distribution indicates that facilities designed for the average male (176 cm) will be unsuitable, even unusable, by a great number of employees. Anthropometric differences have to be taken into account during the design, and include local values when these facilities are designed for export (*for example, 50% of Vietnamese people are less than 165 cm tall*).

Laterality

the left-handed

Around 10% of women and 13% of men prefer to carry out all tasks with their left hand, but many more prefer this hand for certain tasks only. All working environments should be designed to allow the left-handed to work without difficulty.

Vision

the colour-blind

Around 8% of the male population is colour-blind. This means that if, on a screen, we show a red block that changes into a green block, by this simple fact we render 8% of the male population unfit for the task (and the most competent operator may be amongst them). If the block also changed position or shape, everyone could continue to work.

More than half the working population suffers from at least one type of visual defect. In fact, it is abnormal to have perfect vision. Short-sightedness is the most evenly distributed defect: it affects practically everyone after they reach 50. All operations should be able to be carried out by operators wearing glasses, including within protective equipment.

Ageing

older but more experienced

In 2015, between one in three and one in four employees will be aged over 50. Ageing means both an increase in experience and the deterioration of some physical capacities. If an older employee tries to do things in the same way as a younger colleague, he will almost certainly find it more difficult, but it is possible that his experience will enable him to adopt a way of working that does not cause him problems. An organization that does not encourage this type of adaptation is more likely to exclude those over fifty than a more flexible organization.

The situations that place older workers in particular difficulty include the impossibility to plan ahead, immediate time constraints, multiple interruptions to tasks, carrying out a number of tasks at the same time, frequent changes in context. From a physical point of view, muscular strength reduces very little with age, but rapid effort and extensive exposure to heat become very difficult. Difficult postures and unsupported balancing positions should also be avoided. Night work is often the biggest source of difficulty after one reaches fifty years of age.

The situation in most companies in the coming years will be that of the coexistence of two populations: a group of workers aged 45 and over and another of workers aged under 30. The harmonious combination of the strengths of both groups requires appropriate management from Human Resources, particularly in anticipating the high rate of retirement and ensuring that young people are properly trained.

Medical restrictions on the aptitude for work

With increasing age, the main medical restrictions on aptitude concern working nights, efforts linked in particular to heat, and putting pressure on the back and joints. These are likely to create difficulties both for the people involved and for the company, for which the management of human resources becomes more complex. The design of facilities and the organization of work can limit the situations that place workers with certain physical limitations in difficulty, and thus avoid exclusions.

4.2 We are all constantly changing

Operations are carried out by people who are not only *different* but also *variable*, as a result of fatigue, events in their lives or biorhythms.

Fatigue

Fatigue implies a reduction in the body's capacity and therefore results in the use of different physiological mechanisms with a higher cost, in order to maintain the same level of activity. **Being tired means having to use more resources to achieve the same result**.

Muscular fatigue is the result of the internal energy resources in the muscles being exhausted, an increase in acidity, and the fact that blood circulation is not able to evacuate waste and provide the glucose and oxygen that are needed.

Nervous fatigue is when the nervous system is no longer able to sustain information processing at the same pace. It results in an increase in errors and omissions and a deterioration of perception. It can also give rise to signs of irritability.

Initially, one is not aware of fatigue. Although their capacities are affected, the person does not realize it. At a later stage the person notices the fatigue and may implement strategies to manage it (asking for help, double-checking). From a safety point of view, the 'unaware' stage of fatigue is particularly critical.

Life events

Life events (conflict, grief, failure, *etc.*) and the emotions that these events generate, can affect a person's physical state, his perception, the decisions he makes. For example, information seeking will be more limited, reasoning will include fewer factors, and decisions will be less nuanced.

If the origin of these events is individual, the other members of the work group can usually compensate for the variations in the state of that person. If, however, the origin is collective (conflict with superiors, accident of a co-worker), it becomes a "common mode" of failure and the perceptive and decision-making ability of the team can be altered.

Biorhythms

our body changes over a 24-hour period

The human body, like that of animals and plants, has internal clocks. Some biological phenomena are periodic, repeating approximately every 24 hours (there are also monthly and annual rhythms). Body temperatures, the secretion of many hormones, vigilance, sensory motor performance, *etc.*, thus vary over a day.

These daily variations are the result of two phenomena. One the one hand there are internal clocks that continue to function even in the case of experiences known as "free running" where subjects are deprived of all external information. On the other hand, these clocks align themselves with social time, as a result of a number of "zeitgebers"[1] or "synchronizes": the clock, the alternation between day and night, meal times, bed times, *etc.*

In the case of "free running" experiences, periodicity remains, but it shifts from a 24-hour cycle and settles, for certain functions, at around 26 hours. The body clock of a person who is "locked up" is disrupted in comparison with that of the outside world. For someone who works in the day and sleeps at night, all the zeitgebers are synchronized. The biorhythms will align coherently amongst themselves and with social time. For someone who travels from

[1] Zeitgeber: from the German word for *time giver*, an external cue that synchronizes an organism's internal timekeeping system to the earth's light/dark cycle.

Paris to New York, all the zeitgebers are synchronized between themselves, but they are out of step with the traveler's body clock. Over a few days they will align themselves with the new local time. However, for someone who works at night, there is a contradiction between the zeitgebers. We go to bed when it is daytime and work when it is dark. If night work continues for long periods, this creates an upset in the biorhythms and has effects on health. The rhythm never totally reverses itself, as a result of the resynchronization of the zeitgebers between themselves and because, during his non-working time, the person resumes a daytime existence.

If the alternation between daytime and night work is rapid (2 or 3 nights of working in a row), the biorhythms remain closer to those of someone who works during the day, but obviously the person will not be in the same state at night as he is during the day. It is illusory to hope that vigilance and reaction time at 3 AM will be the same as at 3 PM; it is physiologically impossible. The design of control systems and the organization must allow the process to be maintained within acceptable limits, even though the reactive capacity of individual operators will be inevitably reduced at night.

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5

The brain and human reasoning

Human behaviour and reasoning are affected by both the biological properties of the brain and by the characteristics of the situations in which people find themselves.

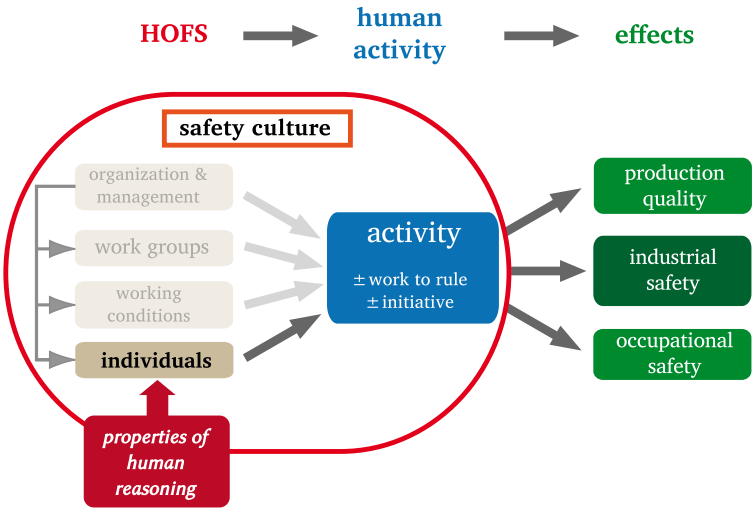


Figure 5.1 – *The subject of this chapter*

First, we will outline some of the properties of the human brain and memory. Then, we will underline the influence that the situation itself can have on reasoning.

5.1 Some properties of the human brain

Many analogies are made between how the human brain and a computer operate. They often lead to false conclusions about reasoning in the working environment. Some properties of the brain and human information processing should be highlighted and taken into account.

An active search for information

The sensors that enable our perception are not passive: for example, our eyes are not like a camera that simply transmits an image. They explore space, guided by the brain. Information is actively sought out, according to the action underway and the person's experience. Information that is not looked for will be much less easily perceived than information that is.

An active search for information facilitates perception

If a new sign is placed on a machine, it is likely that the operator will not see it because he is not looking for information in this area (in the same way that it is unlikely that someone would notice a new "no entry" sign in their street).

The same is true of all the senses: the brain prepares them to detect certain information. Information that is not actively sought must have much stronger physical characteristics if it is to be perceived.

what we are not looking for, we perceive less

Focusing attention

When we are waiting for a bus, we will barely notice all the vehicles that pass and are not buses. If a bus arrives, perception will alter to focus on the number of the bus and no longer on its general shape.

Perception is thus a downward process (guided by the brain) and also upward (the information received will alter the rest of the exploration).

Sight and hearing are the senses that have been the subject of the most research, but in the working environment there is also a wide use of touch, smell and proprioception (perception of the acceleration of parts of the body, felt for example when we stand on a conveyor belt or when a vehicle starts up).

Simultaneous operation

All the senses are thus treated simultaneously. The brain uses all this information to generate an appreciation of the situation. This explains why it is sometimes very difficult to organize the information coming from different channels into a chronological order, particularly when there is a lot of information being provided. Did the light come on before or after we heard the engine start up? Difficult to say. When incidents are being analyzed, people who have lived through them talk of a "simultaneous present": in their memory, everything happened at once.

Shape recognition

our brain recognizes configurations

Information available to our senses is infinite. It is not processed in an analytic manner: **our brain distinguishes shapes and configurations**, some of which are innate (recognizing the shape of a human face) and others acquired (*recognizing a configuration of alarms that corresponds to a particular state of the process*). Our brain selects and combines figures in order to bring them closer to a known coherent unit.

pattern matching

This capacity to identify overall configurations allows the human being to rapidly "recognize" a configuration that "resembles" another, without them having to be absolutely identical. This tends to be an advantage, making it possible to process situations by analogy. However, it can be a problem if, on that particular day, the importance lay in what was different and not in the similarity.

The brain is a gland

the transmission of nerve impulses is chemically sensitive to emotions

Our nervous system is not a system of electric cables. It is true that (electric) nervous impulses are transmitted across the neurons in a stable manner, except in the case of neurological diseases. But each neuron is linked with many others upstream and in general a large number downstream (although it may also end in a muscle). And these neurons are not connected to each other by electric terminals. Between two neurons is a space called the "synaptic cleft". When the nerve impulse arrives, the first neuron emits one or more chemical neurotransmitters, which will cross this space and fix onto the membrane of the second neuron, causing a new nerve impulse to be generated. The nerve impulse is transmitted across the synapse by chemical messengers. But the synaptic space is not empty: it is bathed in extra-cellular fluid, which may contain other neurotransmitters (particularly if the person is in a situation of stress or strong emotions) or the residues of medicines or drugs. The synaptic transmission will then be modified and the various downstream neurons will not be activated in the same way. The chemical transmission of the impulse is altered by the state of the person.

The brain itself is not only made up of neurons. Notably, it contains a gland (the pituitary gland, or hypophysis) and bunch of special cells (the hypothalamus) that secrete hormones, chemical messengers for a number of organs. Other glands, notably the suprarenal glands located just above the kidneys, secrete other hormones. The liquid in which the synapses are bathed is therefore variable, sensitive to the various regulations of the body and to emotions (see "Stress" in chapter 8). The processing of information by the human brain (the rapidity, but also sometimes the results) is likely to be affected by these endocrinal alterations.

We know that certain drugs can increase or diminish vigilance, the visual field, speed of reaction, the perception of pain, short-term memory, *etc.*: the psychological state of the person will in turn alter the body's "internal drugs", producing very similar effects.

These mechanisms will notably affect the way a person builds an appreciation of a situation, such as the process he must operate.

5.2 Building situation awareness

The human being does not build his action from the "reality of the situation" because, as we have already said, this includes an infinite amount of available information. Rather he builds an "appreciation of the situation" or *situational awareness*[1] that combines perception and preparation for action.

Building a representation means preparing oneself

Through perceptive exploration, the brain will retain only some of the available information: that which it considers to form a coherent unit, and which will guide his actions in the situation.

The situation determines your appreciation

An operator has an appreciation of the normal situation in the zone that he monitors, including the noise, the smells, and the usual vibrations. He will be alerted by a change in this overall configuration.

A diving instructor taking a group on a dive spots some groupers and shows them to his fellow divers. The underwater flora and fauna are part of his appreciation of the dive. If an incident occurs and he has to save someone, his appreciation will be focused on the relevant elements that will ensure a safe return to the surface. He will most probably not notice any rare fish in the vicinity.

Experience and training have allowed each person to accumulate a stock of significant configurations (what we call the "mental model"), which serve as a basis for the construction of an appreciation of the current situation.

Mental model

Definition

The mental model that an operator develops about a process includes many normal configurations and possible incident configurations that he has experienced personally or been taught about. Based on this "library" he will either be able to immediately identify that he is in a known state, for which a sequence of actions is available, or he can detect that the situation does not correspond to any familiar configuration and will switch to another way of reasoning (for example he will open a procedure).

Through this characterization of the situation, the brain prepares the body for certain actions, and makes it receptive to certain types of information rather than others.

The configuration determines the preparation

A car driver who has seen that his level of fuel is low expects the low-fuel light to come on and will look for information indicating the next fuel station.

Building an appreciation of the situation means only retaining certain characteristic aspects, which give rise to a targeted mobilization of the body: it is available for certain events and ready to perform certain actions.

[1] Situational awareness is the ability to be conscious of what is going on around you and understand what this information means now and in the near future. The term was first used by United States Air Force fighter aircrew returning from the Korean and Vietnam wars to designate a decisive factor in dogfights, in being able to observe and anticipate the opponent's move.

Mental representations are operational rather than precise

An mental representation is never precise, because it is based on a selection of information. The brain selects the information that it considers to be relevant, according to how it understands the situation and from the orientation of the action.

▷ The same person will not always select the same information; it will depend on his goals.

Our perception is directed by our goals

When the driver takes the place of the passenger, he does not have the same appreciation of the environment, the landscape: he does not select the same information; he is not prepared for the same actions.

our mental representation deforms and accentuates what is significant

▷ Our mental representation is not only based on a selection of information, it tends to accentuate certain relevant characteristics: our mental representation is an **operational caricature**.

Our representations distort ...

Endocrinology students who make casts from the palpation of patient thyroid glands produce models that are more "exact" than those of experienced doctors! This is because the doctors accentuate the growths that they have detected, whereas the students have made accurate casts because they didn't detect anything.

▷ Two professionals with different occupations will create different appreciations of the same situation, each one accentuating the characteristics that are relevant for their own action. This can result in conflict between occupational groups.

To each his mental representation

For the outgoing and incoming teams, the shift change at 6 AM is an essential moment for sharing information on the state of the process. For maintenance subcontractors who are waiting to have their work permits signed, this can seem like a very long chat.

What makes one appreciation take precedence over others?

The appreciation that a person makes of the situation depends mainly on the following four elements:

- the **nature of the information available**
- **personal experience**, which results in personalized mental models, and a library of configurations that the brain recognizes.
- the **purpose of his current work**: if the operator is focused on the resolution of an incident, he will be acutely aware of all the information that he is expecting or looking for to manage this situation. It is possible, however, that he may miss information relating to the start of a second incident that is independent of the first.
- the **interactions with the work group**: in certain cases, interactions with other operators can make it possible to integrate information that had not been identified and thus modify the appreciation of the situation. They can also sometimes play a part in blocking the whole team in an inappropriate appreciation (*tunnel vision*, see chapter 7).

The nature of the information

If the warning light is not working, there is less chance that the operator will realize that the motor is overheating.

An employee's experience

A visitor will attribute no meaning to a series of alarms in a control room. His mental model of the scene is very sketchy. The incoming operator immediately identifies a specific configuration of the unit.

5.3 Memory

Memory is generated by three different processes: sensory memory, short-term memory and long-term memory.

Sensory memory is a sort of "buffer memory" where information detected by the senses is stored for less than a second before being processed. If it is not processed after this timeframe, the information is lost.

Short-term memory is the result of an initial selection (which depends on the mental model of the individual and the orientation of the action at that moment) and thus of filtering. It consists of information on the present situation to be used for dealing with it. It has the following characteristics:

- it has a very limited capacity in terms of the number of units of information that it can hold;

Memory with a limited capacity

We can memorize very few of a list of randomly read numbers. Structuring them in meaningful blocks makes it easier to retain a larger quantity of basic information: it is easier to memorize 101 202 303 404 than 10 12 02 30 34 04.

short-term memory is a weak point of the human being

- it is very sensitive to interference;
- the memory of language-based information can be improved through self-repetition, but the same is not true of precisely recalling a colour or a sensation.

Short-term memory is a weak point of the human being, and it is dangerous to allow safety to rely on this ability.

Memory with limited reliability

An operator who has to take readings from one side of a room then cross it and enter those figures in a system on the other side, is highly likely to make a mistake, particularly if there is a lot of interference (conversations, telephones, alarms, etc.).

Long-term memory contains traces of situations that we have experienced. It has almost unlimited capacity, but has one very specific characteristic: it is impossible to know whether something has been memorized.

Remember that we remember...

Where were you on July 12th 1998? If you remember that it was the date of the World Cup final, you will easily be able to answer this question.

Failing to recall something stored in memory simply means the wrong method was used. Some other recall method might make it possible to find the information in question. The possibility of accessing information from long-term memory is particularly dependent on the similarity between the circumstances in which it was acquired and those in which it is recalled.

The method of memorization influences access to the memorized information

If you try to remember how many days there are in April, you'll easily manage it using the rhyme you were taught at school: "30 days has September, April, June and November..."

But the long-term memory is not simply a memory store. The **memorized traces are constantly being reorganized**, in comparison with the situations in which we are placed. In this way it creates "groups" of similar situations, where common elements are strongly memorized, whereas the elements that are specific to a single situation are more difficult to recall. The memory thus generates summaries that are accessible to the conscious mind of situations where the details are not so easily accessed.

long-term memory classifies situations

A familiar scheme of action

The smell of gas in my house leads me to check the gas taps in the kitchen and, if they are closed, to examine the boiler. If these checks are negative and the odour persists, I will call in the gas board.

These memorized and summarized elements are very diverse: perceptual memories *(the fragrance of a perfume, the words used in a conversation, a landscape)* and sensory motor memories (of the run-up needed to jump over a stream), phrases learned during training *(the ideal gas law)*, descriptive diagrams (such as a process diagram), formal rules *("if the temperature of the reactor exceeds 250°C, stop the reactor")*. But also rules of experience *("every time I have done this, it has produced that result")* and **action schemes**, which bring together the perception of the situation that sets off the action, the sequence of operations, and the search for information to manage a given situation:

For an operator with little experience, the response to an unfamiliar situation will often involve applying a formal rule that he has been taught or has found in a manual. Experienced operators develop action schemes; mental units that establish a link between the observed elements and the actions to perform. This second way of functioning uses much fewer resources than the first (see §5.4 below).

Constant learning

We are thus constantly learning, storing and summarizing the traces of our experience. Of course, we also learn during designated training periods. But it is not certain that the knowledge acquired during training forms a harmonious whole with that which results from experience.

Knowledge is activated in a professional situation because of the similarity of the situation with the circumstances of acquisition.

The difference between a learning situation and a real situation

If we have taught Ohm's law in the format $U = R{\cdot}I$, the question "U =?" will easily generate the answer $R{\cdot}I$. However, this does not prove that when faced with an electrical problem, the person will be capable of applying Ohm's law.

If, during a training session, a situation similar to that experienced in the professional context is created, the new knowledge may be assimilated into the summary made by the brain for these groups of situations. Otherwise, it is likely be grouped with many other statements, ready to be used only in a situation that resembles a teaching environment.

The forward-looking brain and its simulations

our brain anticipates

The brain, as we have said, does not just wait for information to reach it. Based on its anticipation of the consequences of actions that are underway, it undertakes perceptive exploration, anticipates the information that this exploration should provide and checks that things are happening as planned, through sampling.

The brain is constantly making predictions, using its memories of similar configurations. It simulates the consequences of the various possible actions, by activating the same nerve pathways as if the action was really being carried out: only the action itself is not performed. In this way, it compares the various possibilities of action and their consequences.

Being misled by similarities

Doctors know that much more serious conditions start with the same symptoms as a throat infection. They are trained to look for the existence of other concomitant symptoms.

The brain projects onto the world what it has compiled through experience. This characteristic makes the human being very effective at dealing with situations that are similar to those that it has already experienced but with some differences. However, the risk is that a situation be identified by its similarity to others, whereas on this particular day it is the differences that are the determining factor. This will depend in particular on whether the types of situation stored in the memory include *poka yokes*[2], which alert the brain to the need to shift to another mode of reasoning.

[2] *Poka yoke* is a Japanese term, derived from lean manufacturing theory, for a mistake-proofing mechanism which helps an equipment operator to avoid mistakes.

5.4 Forms of reasoning and controlling action

What we have explained earlier shows that analytic reasoning based on formal knowledge makes up just one of the types of human reasoning, which is relatively infrequent in the majority of workplace situations. We can identify three categories of reasoning.

Action-reasoning. Most of our reasoning can be described as very short associations between a configuration of information that the brain recognizes, and a predefined sequence of actions to deal with the situation thus identified. It is these associations that we have called "schemes". In this way, experts in a particular field immediately identify configurations that can be extremely complex for a layperson. This identification is very tolerant of minor differences with the standard configuration. This "action-reasoning" has the advantage of being very economical in terms of cognitive resources.

Action-reasoning when driving

When we see a red light, we look in the rear-view mirror and we brake. We don't think "this is a red traffic light and article R412-30 of the French Highway Code states that all drivers must come to a complete stop at a red traffic light".

Rule-based reasoning. To manage a situation where the configuration is not immediately associated with a sequence of actions, we can use rules that we have learned during training *("if the alarm rings, everyone must go the assembly point")*, or from our more experienced colleagues *("if this pipe is hot you should check the discharge pressure")* and, more generally, that we have learned throughout our life *("if you don't know something, it's best to say so")*. This reasoning mode uses more cognitive resources than action-reasoning, but it remains relatively economical if there are a limited number of rules that are known or easily accessible and do not include contradictions.

As we explained earlier, when the same rule is used often in similar situations, it ends up being incorporated in a scheme, a sequence of information gathering and automated action. This explains why an expert does not necessarily know how to explain the rules that underpin his reasoning, because they have become part of his body's ability to manage a situation.

Rule-based reasoning

To solve the equation $x^2 - 3x + 2 = 0$, most sixth-form students will use the discriminant function. A mathematics professor will immediately recognize a configuration where the roots are 1 and 2.

Knowledge-based reasoning. In a situation where there is no immediate response, no appropriate rule available, or where the rules are contradictory, we will use all our knowledge (both general and professional) to try and find a solution. We will attempt to produce many descriptions of the problem, in order to see where the reasoning process takes us; these results are evaluated, which leads us to pursue one particular route, to abandon another, maybe even to go back a stage.

This mode of reasoning is rich in creative potential and allows us to build appropriate responses to completely new situations. But it is extremely costly in terms of cognitive resources, very sensitive to interruptions, and cannot be maintained in the long term if the context is constantly changing. It is a way of reasoning that only really works well in a calm environment, without immediate time pressures.

5.5 We have limited resources for processing information

Human cognitive resources are limited. Laboratory experiments have allowed scientists to saturate the brain's processing capacity. The result is an increase in inaccuracies and errors, a reduction in caution and greater irritability. Furthermore, if we perform this experiment with two tasks instead of one, we witness an even more significant deterioration: The allocation of resources between the two tasks also consumes available resources. Competition between the tasks is particularly strong when these require the same type of resources. On the other hand, it can be possible to do tasks simultaneously if they call on different resources.

Interference between tasks

We are unable to simultaneously memorize a list of figures and answer the telephone. We may be capable, however, of answering the telephone and drawing.

The information processing system of experts in a particular field does not have a greater capacity than that of novices. But they manage their cognitive resources better, thanks to a number of mechanisms:

experienced people manage their cognitive resources better

- they have automatic "action-reasoning" sequences for a large number of configurations, which is very economical as it allows them to free their attention for other areas of the process;
- they manage their attention in a selective manner *(a novice will look for information everywhere, while an experienced person checks the key points)*;
- experienced people anticipate a lot and can call on a range of alternative scenarios of events and action plans for which they are prepared, which means they are not taken by surprise;
- experienced people know their own resources and limits better: they take them into account in the construction of their action plans, which means that they avoid setting out in a direction that will cause them difficulty. Furthermore, they are likely to better identify the moment where their own resources are no longer adequate and where they need to draw on external support[3];
- experienced people are more aware of what assistance is available. For example, they know in which areas they can count on a particular colleague, how a particular document can be useful, *etc.*

Where safety is concerned, it is therefore essential to take into account the fact that a situation which is managed without difficulty by experienced people can completely overwhelm less experienced colleagues, even if they have a much higher level of university education: knowledge-based reasoning requires far more resources than action-reasoning, as does untargeted research for information compared with a targeted search, reaction rather than anticipation and getting "bogged down" rather than seeking assistance.

5.6 Some frequent reasoning biases

Research in psychology, and particularly in social psychology, has shown that human reasoning can be influenced, or even biased, by certain characteristics of a situation. These biases can affect the reasoning of an operator carrying out a process, as much as they can affect managers defining a safety policy or the members of an occupational health and safety committee. It is essential to be aware of this and the fact that organizational measures often have to be implemented to limit their effects.

The influence of the situation on reasoning

The same research reveals the influence of "attitude", the state of mind with which we approach a situation or the resolution of a problem. This state of mind guides the way in which we look for information and the way we interpret it to draw conclusions and guide our action. Below we will see some examples, which correspond to statistical probabilities. Obviously, other types of behaviour are possible than those that the experiments show to be the most probable. But the general trend should act as a warning to the organization.

A self-limiting belief

A student who is convinced he is weak in English will interpret any poor marks as a confirmation of this weakness and any good marks as an "accident".

Starting point bias (or anchoring bias). It is difficult to shake off a first impression. This first impression influences the rest of our perception. Any information that confirms it is registered more clearly than that which subsequently contradicts it.

In a diagnosis, information that confirms the initial hypotheses is favoured, while that which challenges it risks being under-estimated.

This bias can also affect the judgment that we make of a person: a positive first impression of one of their characteristics makes it more likely that we will find their other characteristics positive (the same goes for a negative first impression). It even affects the characteristics we assign ourselves (self-limiting beliefs):

[3] Social effects can go against these effects of experience: a person with a higher rank will be afraid of losing face if he shows his subordinates that he no longer knows how to manage the situation on his own.

Framing effect. The way a problem is presented (or *framed*) influences the information-seeking process, the reasoning, and its result.

Influence of the presentation of the problem

People were shown a silent film[4] *where they watched two people having a discussion. They were then asked to evaluate the personality traits of the two people in the film. But first some of the group were told that person A was a social worker and person B had social difficulties, whereas the rest of the group were told the opposite. The subjects tended to attribute the "calm, professional" personality trait to whichever of the two people they had been told was a social worker, and the "agitated and worried" traits to the person who had been designated as having social issues! The members of the group had not seen "the same film".*

we see what we believe

When something occurs, we are more likely to spontaneously "see (or hear) what we believe" than believe what we have seen or heard. If a manager or an employee representative is convinced that incidents are due to human error, he will have no trouble in finding examples of human error when examining the course of the event. This interpretation is not the only one possible and it is rarely the most appropriate in terms of prevention (see Chapter 7).

Attributing causes: internal cause or external cause? When we seek to attribute an event to a cause, we can talk of:

- "external" causes (situation, context, divine will, *etc.*);
- so-called "internal" causes (the skills or personality of an individual).

attributing events to personality traits

Research shows that, in Western countries today, when someone (A) is looking for the causes of a situation in which he is not involved, he will tend to favour internal explanations: someone else (B) is the cause of the situation. He will probably underestimate the factors linked to the situation. The risk being that A may then think that it will be enough to change B (by replacing him or training him) for the event never to happen again. Situational factors, like technical and organizational causes, will often be neglected.

However, if A wants to explain a situation that concerns him personally, he is more likely[5] to mention internal causes if the situation is positive (thanks to him) or external causes if the situation is negative (the context led him to…).

These observations are not a moral judgment (that would equate to giving specific people social reasoning characteristics). But incident analysis methods should take them into account, so that the notion of cause is not confused with that of responsibility (see Chapter 7).

Survivorship bias. Individuals or organizations that have lived through dangerous situations without coming to any harm, include in their experience the fact that 100% of challenges so far have been successfully met: these are therefore not so dramatic. Individuals or organizations who have not survived do not testify. The evaluation of risk by "survivors" frequently results in an underestimation.

Group-think. In certain cases of group meetings, we can note that the members of the group favour reaching a consensus, which means that everyone aligns themselves to what they believe to be the opinion of the others, partially losing the link with reality. The group can exercise a pressure for conformity, which results in pushing out opposing opinions, maybe even the people who voiced them, and can lead to the self-censorship of participants. These effects can result in a poor decision being taken, against the individual position of each of the members! Some organizations try to protect themselves from these effects by, for example: encouraging the presence of a "devil's advocate" who will defend a position that is contrary to the consensus-generator; separating the group into two sub-groups who report their results; or allowing points of view to be expressed anonymously, *etc.*

devil's advocate

[4] This experiment was conducted by F. Le Poultier.

[5] In the statistical sense; this is the result of experiments in psychology.

Dilution of responsibilities. This social phenomenon does not affect the fact that, if each of the individuals present had been the only witness to the event, they would have immediately done what was needed. It is not the personality traits of the individuals present that explains the situation, but the characteristics of the situation itself. This mechanism should be taken into account in safety organization: It is an illusion to think that the more operators who are present in an area, the more likely it is that an anomaly will be detected. The job description of each person could include responsibility for a given zone, while remaining vigilant to other zones.

Social shirking

The more witnesses there are to an accident, the lower the probability that someone calls the emergency services, who thus take longer to arrive.

The link between actions and opinions

We tend to think that people act firstly according to their opinions, convictions or beliefs. To obtain a change in an individual's actions, we therefore look to persuade them, to alter their opinion, in the belief that the change in actions will follow on from this.

Yet this is not the only link. **Humans also act and think according to their previous actions**, particularly when these involve them: for example, a decision for which one is publicly recognized as being the author generates strong commitment. It then becomes difficult to go back on this decision, or to demonstrate behaviour that is the contrary to it. Consequently we witness "escalation of commitment" where although many signs are warning that this is the wrong decision or the behaviour is inappropriate, the person doggedly pursues the wrong direction.

escalating commitment

Commitment bias

This characteristic of human reasoning is very often used in manipulative techniques: we make someone take a decision based on partial information and this person continues to stick to his decision when more complete information should lead him to alter it.

At stake is the link that the person makes between himself and his actions. When someone has the feeling that they were freely at the origin of an action, having to carry out an opposing action is experienced as a questioning of himself as a person, and he will do all he can to avoid it.

Yet, we have clearly shown here that behaviour and reasoning are not only the reflection of the personalities of the individuals involved, but are also greatly influenced by the situations in which these individuals find themselves placed. When the situation repeatedly leads someone to produce acts in which they do not recognize themselves, they find themselves in a state of "cognitive dissonance", which is very costly from a personal point of view. In this case a choice has to be made. The person can work on the situation to make it more compatible with his beliefs and thus reduce the contradiction. Or he does not have enough control over the situation to do this, in which case we run the risk of witnessing a "rationalization" phenomenon: These are the attitudes and the frame of mind that develop to reduce the contradiction.

cognitive dissonance

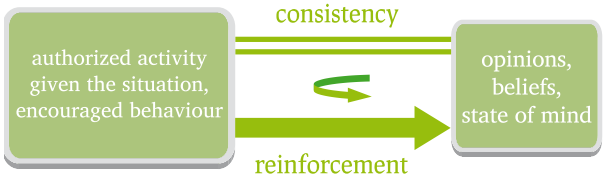
Adjusting beliefs...

During the course of his career, an operator, Mr N, moves from factory X, where safety is taken very seriously, to factory Y where some of the safety precautions are criticized by management as being a waste of time. If Mr N does not manage to convince his superiors of the importance of the precautions that he takes, it is highly likely that he will end up convincing himself that process Y is less dangerous than process X. He has adjusted his convictions to the behaviour that situation Y allows him to have. His cognitive dissonance will thus be reduced.

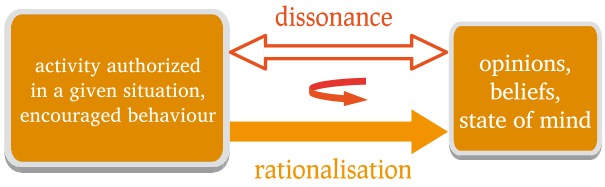
The links between convictions and actions are therefore not only in the direction:

The situation can also exert a very significant influence on the actions that are possible within it, and thus on behaviour; and finally, through the mechanisms of cognitive dissonance and rationalization, on attitude and opinions.

When the situation encourages behaviour that is in line with our convictions, the latter are strengthened:



When the situation does not allow the activity to develop in a way that is in line with our convictions, the situation of cognitive dissonance can lead to a modification of the latter, to make them compatible with what it is possible to do:



These mechanisms are essential in the definition of an industrial safety policy. Messages that aim to convince the people in a company of the importance of safety, but whose implementation *in situ* is contradictory to other demands, play a large part in convincing a number of employees that "it's not that dangerous".

On the contrary, any measure that ensures safe actions are not only possible but encouraged and valued, will contribute to developing attitudes that are favourable to safety.

Objectives which we can relate to

Being able to identify with one's actions is essential both for the individual's health and for the consistency of his actions. When an organization wants to obtain certain types of actions (for industrial safety, for example), the justifications for this constraint can be more or less in harmony with the convictions of each individual. We could, for example, justify the request that workstations be free of all obstacles "because the 5S method requires order and tidiness". We could also give another explanation for the same request: "because clear workstations make operations safer and mean that serious accidents are less likely". These are two different levels of identification. It is likely that an operator will better relate to the idea that tidying up contributes to preventing serious accidents rather than the fact that it respects the 5S method. But the example is not as trivial as it seems: the justification by the "5S method" only requires the organization to respect all the constraints of this method (otherwise the justification would not be taken seriously by the operator). Whereas the justification of "preventing serious accidents" will only be taken seriously if the organization implements a number of other preventive measures that are coherent, including those which the operator considers to be essential to guarantee safety. Any inconsistency between what the company says and what the company does will place the company's employees in a state of cognitive dissonance. It is quite probable that they will then find good reasons to justify post-event that this contradictory situation had obliged them to do things against their will. This leads to a series of attitudes and types of behaviour that are not particularly favourable to safety.

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6

Work groups

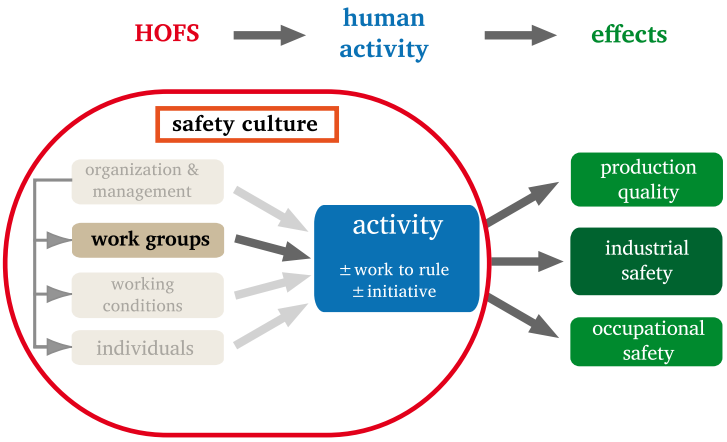

Figure 6.1 – *The subject of this chapter*

6.1 Each person belongs to several groups, each with its own standards

A single person always belongs to a number of different social groups, with more or less clearly defined boundaries. An employee can belong simultaneously to:

- ▷ one or more work groups;
- ▷ a trade or occupational group, which we will discuss later;
- ▷ a professional group, that is to say a group of people with similar status issues;
- ▷ sports clubs, associations, trade unions, *etc.*

Each of these groups is the bearer of a collective heritage, which will influence the behaviour of each of its members. Perception itself is influenced by membership of a group: This generates a particular sensitivity to certain information and creates ready-made sets of interpretations. The group is also the bearer of standards of action that are more or less implicit. A sporting group does not value the same things as a trade union group does. Each person has to develop their own way of behaving, by drawing from a large number of group standards. As a result it is not usually appropriate to believe that the choice of a person can be foreseen, simply because we have identified their membership of *one* particular group. However, there are situations where the various groups mentioned overlap greatly, which increases the influence of group standards on individual behaviour.

group standards

Groups may or may not be formally constituted, include the possibility of internal discussion, put forward a leader, or have an identified representative. It is not always certain that the most clearly organized groups in a company are those with the greatest influence. Yet a change process that does not include influential groups will be very difficult to implement successfully.

6.2 The work group

The work group has a variety of formats:

- its members may or may not work in the same place *(control room operators and roundsmen)*;
- they may or may not have the same functions *(the train driver and the conductors)*;
- they may or may not have the same immediate tasks *(lift a heavy load together)* or just have similar medium-term goals *(produce a particular batch of product)*.

The work group often has variable boundaries (certain functions join in at specific moments) and can include several overlapping circles *(the on-duty team, the on-duty teams)*. A person who is likely to hold a number of positions may have to integrate many work groups.

The work group plays a number of very important roles in the harmony of a production system:

- when the organization allows it, the members of the group can help one other by mutually compensating for the limits (physical ability, expertise) and the occasional difficulties of each individual, going beyond the simple level of teamwork required by the organization;
- the group is an essential level of detection and recovery from an abnormal situation or an error;
- within the group, discussions can take place and solutions be found, when no rule corresponds to the situation;
- a work group that runs smoothly is a positive contribution to the health of its members.

Certain organizational situations can be detrimental to work groups: dismissals, disciplinary action or promotions that are considered to be unjustified, members being placed in competition against one other, the circulation of rumours, for example. When work groups are damaged, we sometimes witness a rapid deterioration in terms of industrial safety: undetected incidents, errors that are normally corrected being left, poor circulation of information. This situation is often accompanied by an increase in absenteeism, particularly due to an increase in minor accidents *(slips, trips and falls, for example)*.

The work group is different from the occupational group.

6.3 The occupational group

The occupational group is made up of people with the same occupation or trade but who do not necessarily work together all the time (electricians or welders, for example).

The occupational rules

Not all occupations are trades. The idea of a trade corresponds to the existence of a historical tradition (that is more or less lengthy) that has led to the drawing up of occupational rules, which define the attitude to be taken in certain situations. When a young person joins a trade, these occupational rules are progressively transmitted and the extent to which they have been assimilated is monitored by the group. The occupational rules mean that everybody has something to start from when they find themselves in a situation that is not totally defined by the formal rules of the organization. The occupational rules are of a different nature to the formal rules: they give a greater scope to the body, to the physical perception of a situation by all senses, to the variability that can arise during an operation.

occupational rules means people do not start from nothing

The occupational rules define a "genre" that is shared by all members of a trade, but they are not incompatible with the fact that each person develops their own "style", within certain limits. Quite the opposite: the occupational group respects individual "styles" and a particularly useful discovery by a member can be integrated into the occupational rules.

Widespread adoption of an individual style

High jumpers used to use the forward roll style jump. In 1968, Dick Fosbury developed a very different style, jumping back-first. The jump was refused at first but then its conformity with the rules was checked. This personal style became widely used and has become part of the "high jump" genre.

Occupational rules are therefore not immutable. They develop through contributions from members and should also evolve through technological, organization and demographic changes. But for this development to take place, "occupational discussions" must be possible. Certain occupations organize conferences for this! Others offer little space for updating occupational rules. **When occupational discussions are inadequate, the occupational rules can find themselves out of step with the development of the means of production**. The "safety net" that they represent is likely to cease to be relevant in certain configurations. These limits are not compensated by formal rules, since the latter do not develop the sensorial and motor skills of operators in the same way.

Furthermore, some occupations are recent and therefore do not have the historic tradition of a trade. It is possible to accelerate the creation of a trade, by creating space for the members of the trade to discuss "cases" they have encountered and for which the formal rules did not provide all the answers. Experiences can therefore be compared, making it possible to identify certain regularities between the responses that have given satisfactory results and those which have not worked. In this way, the occupational rules start to take shape.

The trade and safety

In today's high-risk industries, responsibility for safety is assumed by the organization with the implementation of a Safety Management System. In certain cases, the implementation of a SMS has given rise to discussions with trades, to integrate safety practices that were traditionally valued. Should this interaction not occur, employees can find themselves caught in contradictions between the trade's safety rules and the organization's safety rules. Yet as a general rule it is impossible to decide which of the two is the most relevant:

- the formal rules, which are based on the general knowledge of experts and integrate calculated scenarios that the operators have thankfully never actually experienced;
- or the occupational rules, which are based on the physical knowledge of the facilities and operations and which include local variations that experts are unaware of.

A successful SMS thus requires that the formal rules are established with the collaboration of operators from the various trades involved. Effective coordination of the responsibility for safety by the trades and the organization is one of main challenges of a safety culture (see Chapter 9).

Occupational group and project group

When project-based organization is implemented, it brings together, for a supposedly limited period, a group of people belonging to different trades. The project group forms a work group that allows daily interaction between the different rationales of various trades in order to achieve an objective.

One of the risks is that the members of the project group find themselves in a situation where their interaction with their occupational group is inadequate. Yet the degree of expertise they can bring to a problem, their ability to defend the importance of the professional rationale of which they are a bearer, and the opportunity to keep their skills up to date, all depend on this interaction with their peers in the same trade.

cut off from the trade

A project-based organization must therefore contain space for discussion between members of a trade.

6.4 Trade union groups

Trade union groups form the link between:

- the concerns of site personnel;

- ▷ the directions and resources provided by the trade union organization at a confederation, branch or regional level;
- ▷ the types of intervention of the union representatives with the company management, notably within the employee representative bodies.

The questions that are asked about union representatives are often very similar to those asked about managers: to what extent does their activity manage to coordinate concrete and up-to-date knowledge of the working environment and the activity that takes place within it, with top-down strategic orientations?

The ways in which a union operates are one of the aspects of an on-site safety culture: of course they cannot be defined by the formal organization of the company, but they can play a greater or lesser role in encouraging positive union actions for safety (for example through the responsibilities of the occupational health and safety committee).

6.5 And many other types of groups...

Every individual in a company can belong to other groups: personal networks they have maintained with previous colleagues who are now in other departments, partners for sporting or cultural activities, *etc.* Though they are not professional networks, they are often a source of support or information for our work:

Personal networks can be useful in our work

We can ask a member of our football team, or the librarian who is a member of the choir to give us information on a facility they installed years earlier!

multiple informal networks

These networks also play an important role in circulating information, which means that any contradictions between the messages from the various managers on the site (or by the same manager on a number of occasions) are immediately detected. This can generate a climate of uncertainty and anxiety that encourages rumours and demotivation which can, in turn, affect safety.

The **cohesion** of everybody around the question of industrial safety hinges on the **coherence** of the various signals emitted by the members of management during their daily work (see Chapter 9).

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7

Human error: an inadequate explanation

For many years, "human error" was the most common explanation given for industrial or transport accidents. For many media, this approach is still valid. The underlying model is that all production scenarios are foreseen, that there are clear rules about how to behave in all situations and that in particular circumstances, an individual did not do what he should have done, thereby causing an accident that was more or less serious. Above all, the analysis of the accident should therefore highlight the particular actions that caused the situation to get out of control.

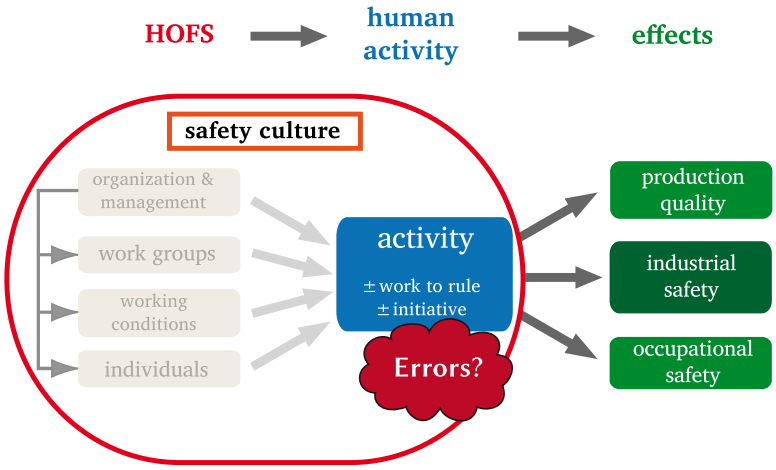


Figure 7.1 – *The subject of this chapter*

This "human error" model as the main explanatory factor of accidents has been discredited for a number of reasons, which will be outlined in §7.1. Errors are most often a consequence of the situations in which those who committed the errors were placed.

> An error is often the result of a situation where an operator and/or a team have not been able to use their expertise, for reasons linked to the design of systems, the interface, the organization, their training, *etc.*

Consequently, avoiding situations that generate or increase errors remains a priority in the design and the organization of high-risk systems. In §7.2 and §7.3 we will explain the ideas behind this, then in §7.4 we will present the main "ingredients" that make errors more likely to occur. §7.5 discusses how appropriate it is to punish errors.

7.1 The limits of the "human error" approach

The vision of the industrial accident based on "operator error" (in the singular) as its main cause has been completely abandoned in the scientific world. The reasons are outlined below:

■ Focusing on human error leads us to examine only the undesirable events that had detrimental consequences, without analyzing all the human adjustments that ensure reliability on a daily basis (see Chapter 1).

ERROR 1

■ Human beings commit many errors. *Who can say they have never forgotten their mobile phone or their keys?* Fortunately, in the majority of cases, these errors are without consequence, as they are detected and corrected by the person involved, or the group, before they generate serious consequences.

ERROR 2

Most errors are without consequence

On a commercial airplane, the observation of 44 successive flying hours allowed 162 errors to be identified, of which 157 were corrected by the crew. Only one error gave rise to a report.

When an error has had detrimental consequences, the first issue should be to understand why it wasn't detected and corrected.

■ We could say that the errors we have just mentioned are "minor errors", whereas those that cause accidents are "serious errors". But each of the contributions to the accident only becomes serious in combination with all the others. The same "error" would generally be without consequence if the context was slightly different.

ERROR 3

■ Saying that "someone committed an error" means that you consider he has done something other than what he should have done. But in order to determine what he should have done, experts build a post-event analysis, taking their time to do so, and have information at their disposal that was unavailable to the person in question at the moment of the incident (particularly information on the fact that the story ended badly).

ERROR 4

hindsight bias

The cognitive processes of the experts who, after the event, reconstruct the actions that would have been more appropriate, are completely different from those of the person who finds himself in the "simultaneous present" of the action.

Clearly, if the person had realized that his actions would have had this result, he would not have undertaken them.

■ Accident analyses often work on the assumption of infinite cognitive resources (see Chapter 5). If the person had been able to take his time to draw on all his knowledge to analyze the phenomenon taking place, perhaps he would have more accurately recognized what was happening. But cognitive resources are not unlimited: at the same moment, the person was monitoring other processes, was interrupted, answered the telephone, *etc.* "Knowledge-based" reasoning cannot be maintained for long in these conditions. The way a situation is handled is always the result of a compromise between the number of events that have to be dealt with in parallel, the rate at which they develop, the depth of the analysis that will be made of each one.

ERROR 5

take into account the limits of cognitive resources

■ Accident analysis often focuses on the error of the person managing the facilities at the time. But his actions are strongly influenced by the **design of the facilities** and the organization.

ERROR 6

Certain technical and organizational configurations are more likely than others to generate the risk of making a mistake.

Certain configurations increase the risk of error

If we reverse the brake and accelerator pedals on your car, even if you are warned and a sign reminds you, you can be sure that sooner or later you will press the accelerator when you meant to brake.

Real-time operating errors are not unrelated to what we call "design errors" or "organization errors" that generate "latent errors" or, in other words, that increase the probability of inappropriate behaviour.

errors that are waiting to happen

Example of a latent error

In the case of the 1988 accident at the Gare de Lyon railway station in Paris, in which 56 people died, one of the factors that contributed to the catastrophe was the fact that a brake valve had the same dimensions as a gas cock, but that it was closed when parallel to the pipe and open when perpendicular. This type of design considerably increases the probability of an error occurring.

■ Focusing the analysis on the last link in the chain does not allow **lessons to be drawn** from the event, nor to put in place preventive measures that are likely to stop it reoccurring.

Today we consider that it is mostly the same mechanisms that enable daily reliability and that lead to the exceptional accident. The system can only work because men and women manage its variability on the front line, using action-reasoning (see Chapter 5) that is generally very effective, thus providing local optimization which is something other than simply executing procedures.

The system never works in a strictly nominal manner. The process is variable in itself, and the performance of the human response is inevitably variable. In certain cases, a set of these variations, which may be completely benign in isolation, occur simultaneously and set off a phenomenon of "resonance". Consequently the effects of the combination are much more significant than the effects of each of the variations.

detrimental resonances

7.2 Lines of defense

The **first level of defense** corresponds to the idea of "barriers": we must stop errors from having detrimental consequences, so we will put in place a series of barriers that are individual, collective, technical and organizational. This is the well-known "Swiss cheese" model proposed by Reason.

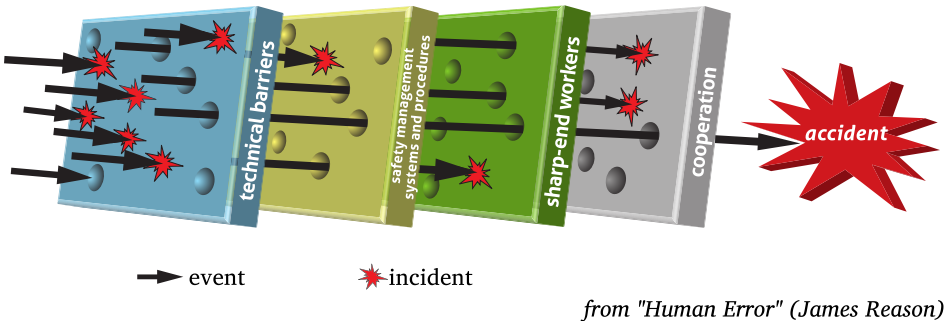


Figure 7.2 – *The "Swiss cheese" safety model*

Some examples:

- individual barrier: *the operator is trained to employ "poka yokes" which are supposed to allow him to distinguish between a frequent incident and a serious but rare incident that starts in the same way*;
- collective barrier: *the flight commander checks the actions of the co-pilot and vice versa*;
- technical barrier: *in a hospital, the oxygen and nitrous oxide tubes do not have the same threads, so that it is impossible to make a mistake when setting them up*;

- organizational barrier: *during a blood test, the correspondence between the donor and the tube label is verified on a number of occasions independently.*

In this model, the initial error will only result in an undesirable event if all the barriers have been breached[1]. The accident analysis is therefore supposed to understand not only the initial event, but also the way in which all the barriers were defective.

barriers do not prevent unforeseen events

This model remains important, but we now know that it is insufficient. Indeed, it corresponds to event scenarios and propagation that were able to be anticipated, which is what allowed the design of preventive barriers. Yet, **combinations occur that were not foreseen** and which are likely to lead to an undesirable result. This situation will be managed if the work groups present on site detect that the variation is dangerous and formulate an appropriate response. Safety will progress if this situation—which in the end was without serious consequences—is analyzed, enriching the range of foreseeable scenarios for which barriers are in place.

We have now identified the "two pillars" that are essential for safety:

- **rule-based safety**, which makes it possible to predefine appropriate responses to foreseeable situations;
- **managed safety**, based on the real-time presence of expertise that makes it possible to identify whether the scenarios are those which were foreseen, and to formulate an appropriate response even if this isn't the case.

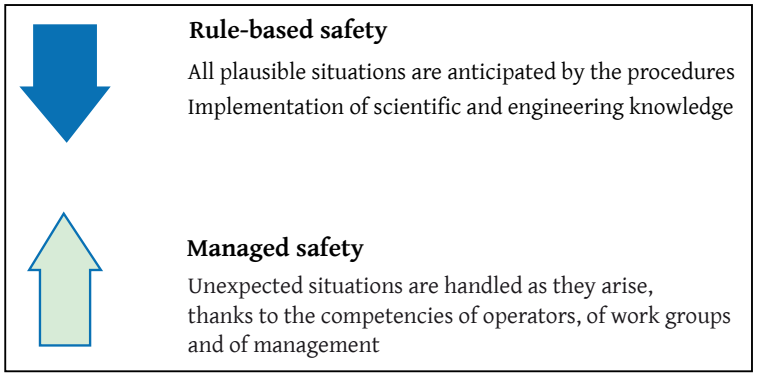


Figure 7.3 – *Rule-based (or regulated) safety and managed safety*

Simply allowing these contributions to co-exist is not enough or may be problematic. A safety culture supposes that they converge with each other and develop jointly.

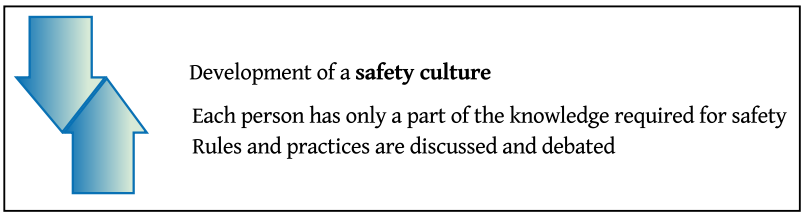


Figure 7.4 – *Towards a safety culture*

[1] This diagram is an interesting image to illustrate the barrier notion. It must not, however, be taken literally: on the one hand the different levels of barriers are not independent from one another, and on the other hand a barrier itself can generate incidents *(short circuit in the motor of a fire door)*.

7.3 Errors, faults and violations

The terms error, fault, violation and failure are sometimes used interchangeably. These terms must be clarified to facilitate industrial and scientific discussions.

Definitions

Definition

Error

An *error* is a situation where a planned sequence of actions fails to achieve its objectives. It is a deviation from an internal or external reference (objective, model, standard, rule, *etc.*), even though the person had no intention of deviating from this reference. **An error is never deliberate**.

errors are unintentional

Definition

Violation

A *violation* is a deliberate deviation from an external reference. Not all violations are necessarily reprehensible: *the traffic light is stuck on red; after some time we will drive through it (violation) carefully, because there is no other solution.*

The notion of *violation* does not include the intent to harm. There are three types of violations:

- some correspond to a situation where respecting the rules bears a very high cost for the operators, but where the consequences of the violation seem limited. In general, these violations are approved by the work group. *Who would wait indefinitely at a traffic light stuck on red?* Of course, the level of tolerance shown by work groups with regards to violations depends on the safety culture of the organization;
- others correspond to the individual "style" of an operator, who takes liberties his co-workers disapprove of;
- and lastly, others occur when the existing rules contradict one another or when it is impossible to follow them simultaneously. In fact, this situation must not be interpreted as a violation, but rather as a case of "knowledge-based reasoning" (see Chapter 5).

Of course, if operators break a rule on the orders of their superiors (as was the case in Chernobyl, for example), this is not considered a violation on the part of the operators themselves.

A violation with the intent to harm (sabotage, for example) is a wrongful or criminal act of a completely different nature.

Definition

Fault

In English, the word *fault* means failure or flaw (in a material or a component). A fault tree is a tree of failures.

Determining whether an operator who has committed a violation has, in doing so, committed a breach of discipline requiring sanction, is not the same as understanding the events in order to determine preventive actions. This point will be discussed further in §7.5.

The term "fault" is not part of prevention vocabulary

Main types of error

The main types of errors are linked to the forms of reasoning that were presented in chapter 5.

- **Some errors occur when performing routine tasks** ("action-reasoning"): these are slips (*thinking one has pressed the button and it is not pressed, or inadvertently touching the switch*), lapses (*typing 17236 instead of 17326*), perceptual confusion (*reading F6 instead of S6*).
  These errors are extremely common (70 to 80% of all errors), but most of the time they are detected and quickly corrected by the operator or the work group. To reduce the probability of these errors occurring, the primary focus must be on good design, which is essential to ensure that this type of error does not have an immediate serious consequence (mistake-proofing, role of order confirmations, of locking certain combinations). Individual double-checking or cross-checking are also ways to reduce this type of error.

slips in a "routine task"

- Some errors occur when **applying rules**. These errors may be caused by rules of experience that until now had been relevant, but which meet with an exception for the first time.

The exception to the rule...

A child has come up with the rule that "to multiply by 10, you add a zero". The child will make a mistake when applying this rule to the multiplication of 0.5 by 10.

errors relating to rules

An error can occur when applying formal rules: the situation can be wrongly identified, leading one to follow a rule that did not apply or to not follow a rule that did apply. Or the rule chosen was the right one, but an error occurred during its application (a step was forgotten, for example).
Errors relating to the application of rules represent 15 to 20% of errors. They are more difficult to detect than the ones outlined previously: the entire work group is sometimes "swept along" on an erroneous assessment of the situation and often it is people from outside the work group who will detect the error and allow its identification. Certain organizational measures can reduce the probability of this type of error: design of procedures, collective briefing before an operation is performed, training on the different scenarios (on a simulator, for example).

- Some errors occur when **applying knowledge**. These situations occur when there is no obvious rule and the operators must draw on all of their knowledge to analyze the situation and decide on a suitable solution. These errors are often described as: "he should have known that..." The fact that existing knowledge was not applied may stem from the differences between the circumstances in which the knowledge was acquired and the actual circumstance (see Chapter 5). Knowledge acquired in the classroom is not necessarily applicable in real-life situations. What's more, **cognitive resource limitations** must be taken into account within the context of the situation.
Knowledge-based errors are the least commonly occurring and potentially have the most serious consequences. But these results simply demonstrate the fact that they only occur in situations of "knowledge-based reasoning" or, in other words, in exceptional situations for which there is no clear rule. It is not only the knowledge of the operator that has been show to be insufficient, but also the ability of the entire system to anticipate (it is normal for this to occur occasionally), and the resources (cognitive, technical, organizational) to manage an unexpected situation in real time.

errors that aren't really errors

Reducing the probability of this type of error depends partly on training human resources: teaching methods must be designed in such a way that the learning situations are as close as possible to the situations in which the knowledge will have to be applied (simulators or case studies, for example). The organization must also pay careful attention to the fact that not all situations can be anticipated: real-time availability of support (expert on call), focus placed on experience feedback, analysis of the difficulties faced in applying formal rules.

7.4 Situations that increase the probability of error

Analysis of accidents or incidents reveals families of "ingredients" that recur regularly and have contributed to increasing the probability of an error being made. Here we review these classic "precursors".

Available information

- a piece of information is missing (*blown light bulb; process taken away by the chief for revision*). In particular, this can be information that is missing on a piece of equipment that is on loan or undergoing repairs;
- a piece of information is present but wrong (*sensor drift*);
- a piece of information is correct, but provided by a unreliable sensor and interpreted as "wrong once again";
- an indicator does not necessarily mean what it is thought to;

Problem with interpreting information

At Three Mile Island, the indicator on the relief valve did not, as the operators thought, indicate that the valve was shut, but simply that the order had been given to close it. And yet it remained stuck open.

misleading information

▷ temporary information about repair work coexists in a contradictory fashion with permanent information, even though the permanent information should have been deleted (*white lines not erased properly in a roadwork zone, unconcealed permanent speed limit signs coexisting with the temporary signs*).

Presentation of information and controls

▷ Some indicators or their labels are ambiguous

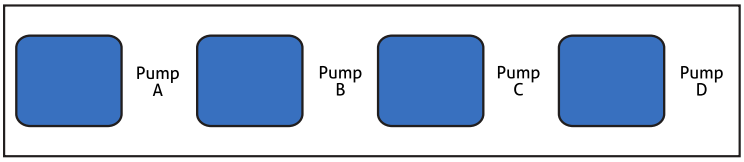


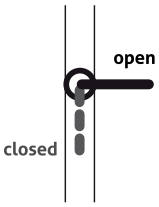
Figure 7.5 – *Ambiguous labels*

▷ Some controls do not match stereotypes
A stereotype is an expected relation between the shape or position of a control and the effect produced when it is used.

Examples of stereotypes

When turning a volume button clockwise, the expected result is an increase in volume. When turning a water tap anti-clockwise, the expected result is an increase in water flow.

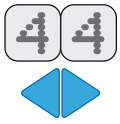
If a device is designed in a manner that is contrary to the stereotypes, the probability of an error occurring is very high (see figure on the left, which illustrates the counter-intuitive design of the brake valve on a French train, and contributed to the Gare de Lyon accident in Paris).



In certain cases, as illustrated on the right, there are contradictory stereotypes; the use of such configurations must be avoided.

How do we obtain the number 45?

In the previous arrangement, the "up/down" stereotype instructs one to click on the top arrow to increase the number to 45. The "previous/next" stereotype instructs one to click on the bottom arrow to move on to the next! If the arrows were "right/left" instead of "up/down", there would be far fewer errors.



43 towards the left, 45 towards the right

In the case of an electronic tap that controls the flow of water, we are caught in the contradiction between the "volume button" and "tap" stereotypes mentioned above. It is therefore better to use a different type of control other than a round button.

Finally, there are configurations for which no stereotypes really exist (*buttons on a 4-burner cooker*) and on which beginners tend to make many mistakes.

Figure 7.6 – *How does one increase the flow?*

Stereotypes have a cultural dimension, linked in particular to the reading direction. Designing devices for countries where the reading direction is not left to right and top to bottom requires specific skills.

Communication

Communication problems often appear in the history of an error that has contributed to an accident.

- the operators involved were unable to communicate (*radio out of order, phone line busy*);
- the operators did communicate, but did not understand one another:
  - incorrect perception of a piece of information *(50 instead of 15)*
  - incorrect interpretation of a piece of information *("everything's fine" did not refer to the same operation for the person giving the information and the one receiving it)*

To prevent this type of miscommunication, some companies impose specific and formal rules of communication *(10: 2 times 5 or 6: 2 times 3, spelling words using the international alphabet)*. This is useful for preventing errors in perception, but only solves some of the communication problems that can occur. The more sophisticated formal communication measures (compulsory sentence structure, checking of the information perceived) are very effective, but only when the structure of the information to be exchanged is predictable.

operational communication

Furthermore, they consume large amounts of cognitive resources *(imagine it being compulsory to read out loud each traffic sign identified along the road)*. In an incident situation, structured communication protocols often give way to more natural expression.

Conducting training sessions in "operational communication", to make work groups aware of these challenges in communication and provide tools to overcome them, is a good solution in the medium term if the training is designed to take into account the realities faced by workers in the field.

pre-job briefing

In fact, communication between two people will be far less open to misinterpretation if each person has sound knowledge of the work of the other and of the process involved. There are far fewer cases of miscommunication within a locomotive crew than between the latter and the maintenance contractors. Since structured communication protocols are very taxing at the cognitive level, it is worthwhile to increase supervision, especially for workers who are not employed full-time, since this is where there is the greatest risk of misunderstandings. **Briefing sessions** (meetings held before a task is performed) are especially necessary when a task requires participation from people who do not usually work together or involves a variable environment or an infrequent operation.

Physical and emotional state

when operators are not in their usual condition

- Working nights inevitably reduces the resources of individuals. If difficult operations must be performed at night, more resources must be provided than if they were performed during the day. Non-routine operations performed at night figure amongst the triggers of many accidents.
- The condition of employees can be affected by fatigue, particularly when working more hours than usual.

- ▷ Fatigue can also be the result of a previous incident: the first incident required great effort from the operators who managed it perfectly, so when the second incident occurs their resources are depleted.
- ▷ A person's physical condition can be affected by a highly emotionally charged event.

Impact of the emotional state

In the French railway system, a train driver who witnesses a suicide under his train is immediately replaced. This was not the case in the past and it was revealed that drivers affected in this way were at higher risk of having an accident on the rest of their route.

A personal event can affect an individual. If the event involves a group (conflict with superiors), the resources of the entire team are affected.

Fixation error, tunnel vision

Human cognition has a troublesome characteristic: once we have reached an assumption, our perception and reasoning tend to cling to all of the information that confirms this assumption, and to underestimate the information that should alert us to the fact that we are on the wrong track (see chapter 5). We can thus become firmly set on a wrong course: standard reasoning systematically favours the assumption of a frequent incident, rather than an infrequent incident that begins in the same way.

proceeding further in the wrong direction

It is quite possible for this "fixation error" to involve the whole team ("tunnel" effect) and not just an individual. Investigations are generally put back on track by an external party who did not witness the beginning of the incident and picks up the analysis with a fresh perspective. This person can only play this role if placed in a situation that allows "knowledge-based reasoning": free access to all information; the ability to do one thing at a time; no interruptions.

Reducing the probability of this type of error depends:

- ▷ on the availability of this type of expertise outside of the real-time team, and on it being commonplace to call on this expertise (even if it seems unjustified!);
- ▷ on the identification of incidental scenarios that begin in a similar way and, as part of training, practicing remaining alert to these deceptive similarities.

The condition of the work groups

Since the Challenger accident in particular, accident analyses also reveal that the condition of work groups has an impact on the risk of error.

- ▷ As stated previously, groups can be weakened by conflicts with management, by disciplinary action or promotions that are perceived as unjust, by disagreement with messages from management. When this is the case, the ensuing detachment even affects perception: detached individuals are less receptive to subtle clues, take fewer elements into account in their reasoning, are not as thorough in checking the results of their actions, are less likely to detect an error made by a colleague. Generally it is not, or at least not only, a case of a deliberately casual attitude: cognition itself is affected.

detachment affects perception

- ▷ Groups can suffer from sudden changes in their composition (*for example several people retiring and several young recruits starting simultaneously*). The common references are weakened; there is an increased risk that synchronization will suffer. When changes in the composition of the group are inevitable, a minimum time frame is necessary to rebuild a common frame of reference.

Taking the time to build common references

An airline captain performs a "safety test" each time there is a change in the flight crew.

The effects of the organization

The accident analysis for the Space Shuttle Challenger in 1986 revealed the role played by the organizational changes that took place within NASA over the preceding years. Since then, much knowledge has come to light regarding **organizational characteristics that increase the probability of an error** occurring and **reduce the chances of it being rectified**. Here are a few of the symptoms of such a deterioration of the organization.

- Productivity pressure (from internal and external customers) pushes the system closer to its operational limits. Contradictions appear between the safety rules and the production requirements, but they are often settled in favour of productivity.
- When an employee warns about this situation, it is usually interpreted as an unwillingness to improve productivity. Raising a doubt is treated as a lack of professionalism, whereas "not having a problem" is looked upon favourably. When employees (and subcontractors) notice a small "anomaly" locally, they improvise a solution instead of reporting it. "Transgressions" are trivialized.

the productivity-safety conflict

whistleblowers

- The warnings that are expressed despite this negative pressure go unheeded, as they are attributed to "professional complainers".
- Departments and teams are made to compete both internally and with subcontractors. Retaining information becomes a strategy for performing better than the "opposing" team. *Maintenance service reports almost always bear the mention "NTR[2]".*
- The official line on safety remains unchanged or becomes reinforced, but the information exchanges that could have existed on the front line (experience feedback on incidents, participative elaboration of procedures, *etc.*) are suspended because they add no immediate value.

when messages from management are disconnected

- Communication campaigns from management are disconnected from the reality in the field, and interpretation of their meaning is uncertain, even for local managers who must disseminate them and report on their implementation. The supervisory team has doubts about the relevance of the objectives they have been asked to achieve.
- In some cases, convinced that the survival of the site or the company is at stake and prompted to action by the misgivings felt by employees with regard to the reorganizations, employee representatives themselves do not realize how safety has deteriorated in comparison to the earlier situation which they felt was fine, and they do not consider it a priority to be concerned about safety in these circumstances.
- Work groups are destabilized due to the lack of direction shown by their superiors, the constant organizational changes and an increase in contradictory instructions.

When several symptoms from this list appear, safety is seriously jeopardized. To prevent this situation, a sound "safety culture" must be built. This is discussed further in chapter 10.

7.5 The attitude towards errors: to punish or not

Systematically punishing the "errors" committed by operators (at least those which are visible, because they contributed to an unwanted event) is often counterproductive from a safety point of view:

- the error is designated as the primary factor to explain the unwanted event; the organization thereby absolves itself from analyzing the factors that increased the probability of the error being committed, and therefore does not deal with them;
- the group, which perceives the punishment as unfair, is put in jeopardy and its "safety net" properties are reduced;
- the person in question can be affected, with consequences on their professional performance.

what disciplinary policy?

A high-risk company must have a clear policy for managing errors and violations, which includes the following elements.

[2] NTR: Nothing to report

- ▷ An error is by definition unintentional. Therefore, it does not make sense to punish an isolated error. If the same kinds of errors are repeated, it becomes necessary to check whether they are committed by several operators with the same role:
  - if they are, technical or organizational "latent errors" must be present;
  - if they are not, the training of the particular operator may be called into question, and the occupational physician[3] may be asked whether there is a medical explanation (undetected hearing problems, for example).

  If these precautions are taken, the work group will no doubt consider that it is fair to blame the negligence of an operator who makes repeated errors out of "carelessness".
- ▷ For violations, the situation is different. Violations are deliberate, but not always reprehensible. The system would perform very badly if no rule violations ever occurred, therefore violations cannot all be treated the same way.
  - Some rules are golden. *One must never, ever, smoke in a refinery.* If these rules are presented as such and there is no situation whatsoever in which it is necessary to break them or where a breach might be looked upon favourably, all employees will consider it completely fair to punish such a violation. Of course, it is up to the organization to ensure everything is in place so that it never becomes necessary to break this type of rule.
  - Other rules have always been broken from time to time, and until now this has never caused a problem. Yet, one day they become unbreakable. Employees must be informed and receive an explanation and prior notice before punishment can be considered.
  - Some rules are regularly broken (or bent) by all members of the group because, given the other constraints of the situation, it would be very costly to obey them. If one of the employees is punished for such a violation, a strong reaction from the group can be expected, either in the form of an open conflict if the organization is quite tolerant, or in an invisible manner with a much greater negative impact on safety (work-to-rule, for example).
  - There are cases of "unavoidable violation", in other words cases where the different rules are incompatible with one another (contradictory instructions). Applying a punishment in these cases strips the organization, the management and the rules of all credibility.

    contradictory rules
  - Lastly, there are situations where the casual or dangerous "manner" of an operator is disapproved of by the group, but where the work group does not have enough influence to make the person in question see reason. In such a situation, management loses credibility with its failure to impose disciplinary measures.
- ▷ Violations with the intent to harm (sabotage, for example) call not only for disciplinary sanction, but possibly also criminal charges.

If management decides to take disciplinary action following a violation or repeated errors, it must be in the form of a "directive", to clarify the decision. In order to arrive at a decision that makes a positive contribution to safety, it is essential to take into account both the formal rules of the organization *and* the rules of experience applied by the work group. The person implicated may be assisted by a representative or a co-worker of their choice. This is not only an obligation set out in labour laws; it is also an opportunity for management to improve its understanding of the context in which the events took place and to put forward suitable solutions.

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8

The health of employees and the health of the organization

This document does not focus on the prevention of occupational accidents and occupational diseases, but rather on the prevention of industrial accidents. There are, however, numerous links between employee health and the performance of the organization, which means that **poor management of employee health hazards by the organization can affect the company's operations and industrial safety**.

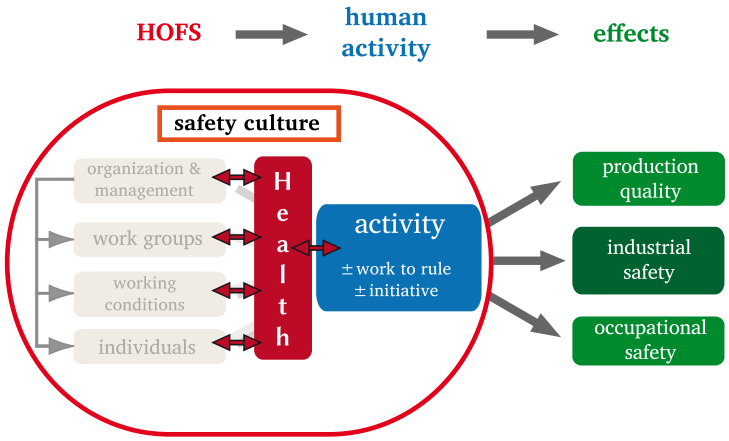

Figure 8.1 – *Employee health, a determining factor and consequence of HOFS*

8.1 Numerous links

The health of employees and the performance of the organization are interlinked.

8.1.1 The health of employees is an issue for the organization

Of course, damage to the health of employees has consequences that are, above all, painful and dramatic for the employees themselves and their loved ones. But it also has many effects on the organization:

- **Absenteeism**, and especially long-term absenteeism, has a significant financial cost, as revealed by studies conducted on hidden costs. Replacing the absentees puts a strain on local managers who must find solutions. Replacements can be sought internally, which often has consequences on the overtime or leave of other employees, or externally with a higher salary cost and sometimes a loss of skills or cohesion within the team.
- **Medical restrictions** are difficult to manage, especially in an industrial setting where work is performed 24 hours a day and operators must have medical permissions to intervene, in case of a fire for example.

- **Occupational diseases and accidents** have a direct cost due to the resulting increase in insurance premiums[1]. Microeconomic studies show that indirect costs are around 10 times higher (disorganization, time spent by superiors managing absences, loss of skills in an occupation, difficulty managing the return to work, *etc.*). The rise in the number of gross negligence cases against the employer—and rulings establishing the latter, which result in higher compensation than through insurance claims—has considerably increased the legal and financial risk of occupational diseases.
- For decades, early retirement was a way to manage **professional burnout** or premature ageing due to working conditions. Now that the retirement age has been raised, this solution is no longer viable. Companies will be forced to keep employees in active employment until they reach the full pension age, which continues to increase. It is therefore important for the organization to not only ensure employees continue to be productive until retirement, but also to correctly manage the transition from one generation to another.
- The **image** a company projects in terms of occupational health and safety is one of the factors influencing their selection by young, qualified job candidates. Companies with a lesser reputation will have a smaller pool of candidates to recruit from.
- Through various mechanisms that will be described further on, we can end up with employees (including managers) who **lack commitment to their work**. The effects can be an increase in individual health problems and absenteeism, an increase in the number of minor accidents, decreased vigilance, deterioration in the quality of the decisions of individuals and groups, a decrease in communication with superiors, and an increase in the number of conflicts that are slightly difficult to understand at first. In some situations, acts of sabotage occur that represent a particular threat to safety, since they are performed by particularly skilled employees. Malevolence towards the facilities cannot be justified by the problems within the organization, but the company must treat it as a serious warning that potential issues exist.
- Certain **addictions** (alcohol, drugs) can have direct consequences on the safety of those involved, their co-workers and the facilities.
- **Suicides** of employees, who in one way or another establish a link between their act and their work, have significant consequences for the company: co-workers and management placed in a difficult situation, social tensions, and media exposure.

All of these factors illustrate that the health of employees is a major issue for the organization, since damage to the former weakens the latter. Of course the organization is not responsible for all employee health issues, but it plays a significant role in some of them.

8.1.2 The organization affects the health of employees

Accidents represent an immediate health hazard. Progressive work-related health hazards have four main causes: poisoning, excessive demands on the body, the disruption of biorhythms, and the deterioration of the psychological attitude to work.

- The risk of **poisoning** by chemical, physical (radioactivity) or biological toxins is dependent not only on the presence of these substances in the working environment, but also on employee exposure. The organization plays an important role in this exposure: design of work resources, planned duration of the work versus actual duration, supply of appropriate tools and equipment, remote transmission of relevant information, awareness of the danger by the operators.
- **Excessive demands on the body** include for instance the manual handling of heavy loads, extreme postures, the repetitiveness of certain operations, and exposure to heat in the working environment.
- **Biorhythm disruption**[2] occurs as a result of the irregular hours involved in night work and can have a significant impact on the life expectancy of the employees in question. In this category, we can also include the effects of frequent jet lag during business trips. Within the industries discussed here, it is not possible to abolish night work, but the

[1] In many countries, the costs of occupational accidents will be borne directly by large firms, and not by the national social security system.

[2] which we could also include in the previous category.

organization can limit its effects on health: choice in planning work hours and leave, provision of hot meals, periods of rest during the night.

- Hazards to the **psychological attitude to work** have been the subject of many studies based on different theoretical models and approaches. Below we present two complementary ways to approach this issue: one is in terms of *stress* and the other in terms of *subjective mobilization*.

8.2 Stress in the workplace

8.2.1 Stress, a biological response

Unsuspected resources

A person being chased by a ferocious dog will manage to run unusually quickly.

Stress is first and foremost the body's response to a situation that is likely to threaten its integrity: exceptional biological resources are mobilized to face it.

The biological response happens in two or three phases:

- **first phase: the warning**
  The nervous system sends a warning to the central part of the adrenal glands, which secrete "fight-or-flight" hormones released by the adrenal glands in response to stress (epinephrine and norepinephrine). These trigger the mobilization of the body's resources: blood pressure increases; blood is pumped to the muscles and brain as a priority; available sugar in the liver is circulated in the bloodstream. This fast reaction leads to a short-term mobilization of energy that allows a person to deal with an immediate situation, but exhausts all the usual sources of energy.
  We can therefore note that in small doses norepinephrine boosts sophisticated reasoning, whereas in high doses it leads the brain to favour the oldest stereotyped responses learned, and immediate preservation rather than preservation in the medium term.

  stress: the body mobilizes its reserves

- **second phase: resistance**
  If the source of stress persists, the body must find other resources. The hypothalamus, followed by the pituitary gland, sends chemical messages that order the peripheral part of the adrenal glands to secrete cortisol. Cortisol enables the body to produce glucose from fats and proteins. It also has anti-inflammatory properties.
  But maintaining a high level of cortisol has toxic effects on the body: it generates metabolic disturbances that cause atherosclerosis (blocked arteries) and cardiovascular disease in the long term, and it reduces immune defenses.

  side effects

- **third phase: exhaustion**
  If the source of stress becomes chronic, there comes a time when the body stops reacting. The biological regulators (and especially the one that regulates the production of cortisol) are overworked and numerous health problems can appear (cardiovascular damage, infectious diseases, allergies, cancers). One possible outcome in the human being is depression. Amongst other symptoms, this manifests as an undifferentiated negative perception of situations and "overgeneralization", in other words an excessive tendency to attribute common traits to different situations, which prevents the sufferer from treating distinct situations appropriately. The ultimate risk is suicide.

  permanent stress exhausts the body

8.2.2 The psychological aspect: facing the situation

Our knowledge of the biology of stress is drawn mainly from animal experiments. The way a human being perceives and manages a stressful situation will of course play an essential role.

For the human being, stress is linked to the requirements of a situation which we *perceive* as probably being beyond our capacities. Believing ourselves to be ill-equipped, we will try to "face" the situation by utilizing cognitive resources and implementing actions. We may try to act by combining two types of response:

situation perceived as being beyond the individual's capacities

- an emotion-focused response: *calming oneself so as not to panic, refocusing thoughts, recalling the rule*;
- a problem-focused response: *when faced with the beginnings of a fire, grabbing an extinguisher and tackling the fire.*

Stress therefore calls for active management. The positive or negative outcomes of this management will play a very significant role in the possible appearance of pathological consequences.

8.2.3 The ability to influence the situation

Animal experiments

An important experiment carried out by Weiss in the 1970s reveals that the effects of stress depend not only on the physical characteristics of the stressful situation, but also on the potential of the person involved to respond actively (see figure 8.2 below).

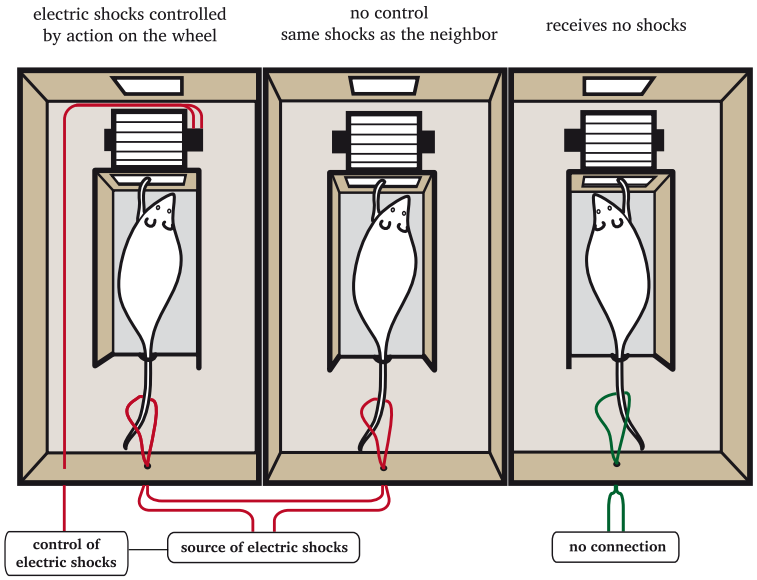

Figure 8.2 – *Diagram of Weiss' experiment*

being able to react to the situation limits the effects of stress

The mouse on the right is a control that does not receive any electric shocks; the stress exhibited by this mouse is a measure of the stressfulness of being constrained in the test apparatus. The mouse on the left is subjected to shocks that are modulated by its actions on the wheel. The middle wheel is immobile, yet the mouse receives the same shocks as the one on the left, despite not exerting any influence. Weiss found that the health of the middle mouse (measured as stomach ulceration) is much more seriously damaged, even though it received the same shocks as the mouse on the left. This is explained by the fact that the mouse whose actions on the wheel have an effect is in a situation where it secretes more adrenalin, whereas the mouse that exerts no influence on the situation secretes massive amounts of cortisol.

Other experiments show that actively exploring the environment and seeking information has a protective effect, whereas abandoning this exploration encourages the appearance of stress-related health problems.

These animal experiments reveal how important it is for the individual to be able to **explore and influence the stressful situation**. Having to passively endure the aggression is what leads to health problems. Other research conducted on humans confirms this.

Karasek's model

A famous questionnaire (Karasek) led to the assessment of three variables that characterize the situation of a worker:

- the psychological demands, which we can liken to the workload;
- job decision latitude, which corresponds to the autonomy the person has to handle this workload;
- and social support (support from superiors and colleagues).

Many studies show that, for equivalent levels of psychological demands, damage to health is more significant when the job decision latitude is lesser and when social support decreases. It is therefore not the quantity of work itself that is pathogenic, but rather the absence of leeway and social support for performing one's tasks. Autonomy is both the leeway that allows someone to carry out their work properly in spite of variabilities in context, and the possibility of active exploration, personal expression and development. Social support (from the work group and the occupational group for example, but we might also add support from the family) makes it possible to avoid facing difficult-to-manage situations alone.

the absence of autonomy is pathogenic

8.2.4 The organization's response

If a permanent high level of stress is noticed in a work group, the only changes to the situation that will have a positive effect are those in which the employees affected will play an active role. A partial improvement does not protect if it is experienced passively.

To deal with the problem, the employees concerned must be allowed to work as a group to precisely identify the situations that are especially difficult to manage, and to come up with suggestions for changes and submit these for discussion within the organization.

If the situation is so serious that significant numbers of affected employees manifest a form of depression, this approach may require (in parallel) appropriate medical support for the individuals in question. This would allow them to regain control, break the "over-generalization" pattern and think about the difficult, concrete situations they are faced with, in order to put forward their own contribution on ways to change these.

8.3 Mobilization in the workplace

Another approach to the psychological attitude to work consists in examining the **mobilization of subjectivity in the professional activity**. What will make one person in particular find satisfaction in a work situation and mobilize a high level of resources for it? What mechanisms can, on the contrary, lead to demobilization?

8.3.1 Each person carries with them a history

At all times, each person carries their own history, etched in their body. This history, and in particular the history of their relationships with others, endows them with a sensitivity and a particular emotional response to certain events, a capacity to detect certain configurations, personal values and standards, and a capacity to take a stand for certain causes.

Commitment to work always entails a commitment from the entire body, a mobilization by the individual of their physical, perceptive, cognitive and social interaction resources.

During the first months of work, it is possible that the resulting financial benefits may be the main reason for commitment from the body to work activities, since these benefits make it possible to realize personal and family goals outside of work. But little by little, many individuals discover that certain characteristics of their work resonate with their own personality traits. **When an individual performs his work well, this brings not only financial benefits, but also a subjective benefit**: the approval of others contributes to self-esteem.

The extent of an individual's mobilization in his work will be on a par with this resonance between the work objectives, the individual's personal characteristics and values, and what others think, since their opinion is important: customers, co-workers, superiors, loved ones. When these criteria are in harmony, the individual can draw on all his resources and derive benefits to his health. Some very inflexible working environments, *such as elite army corps*, provide this resonance to individuals who are very carefully selected and have similar personalities. Other more flexible working environments can offer the same benefits to individuals with more varied personalities. This positive resonance can even appear in situations where the work is considered to be difficult or laborious.

finding satisfaction in a job well done

But this positive resonance is, of course, not always guaranteed. Mobilization and health can then be put under strain.

8.3.2 Defenses

Certain situations in the workplace can be painful to experience subjectively: permanent presence of danger in a high-risk industry or on a building site, suffering of patients in a hospital, repetitiveness of factory line work, aggressiveness of customers in a call center, *etc.*

When a human being is placed in a situation that is difficult to experience and which he **cannot modify in reality**, the subconscious creates a **defense** that consists in **modifying the perception of the situation** (see chapter 5 also).

Defense in the face of danger

when fear is more dangerous than the danger

In a risky situation, a defense therefore involves convincing oneself that the situation is not as dangerous as it seems. In fact, it is not a defense against danger, but rather against fear: it is not possible to work every day in a state of fear; there is a risk of losing one's job. The feeling of fear, which is likely to have immediate effects, is erroneously perceived as more threatening than the statistical and remote risk linked to the danger. The subconscious will therefore work to dismiss the fear by minimizing the perception of the danger.

Defenses are not only built alone: from the moment a young employee is recruited, the group often subjects him to forms of ragging, where he is exposed to dangerous situations and must not show fear. The rapid building of individual defenses is supported by the group.

Like all defenses, those against fear have a positive aspect and a negative aspect. On the one hand, they allow the employees in question to continue to work. On the other hand, by minimizing the perception of danger, they lead to risk-taking.

Some apparently irrational behaviour can be explained by taking into account this defense: engaging in risky behaviour or refusing personal protective equipment is a way of proving to oneself and others that one is not afraid.

Incidentally, it is worth emphasizing that if the organization tries to react to this risk-taking behaviour on an individual level only, there is little chance of a positive outcome: the group is the guardian of the defenses. In order to modify the behaviour just described, the group must be able to develop new ways of reacting to risk, rather than managing the dismissal of fear.

Defenses and the limits of actions

The defenses developed by employees limit their capacity to act on a situation, to point out the problems encountered, to collectively elaborate solutions and discuss their implementation. But on the other hand, defenses originate from these limits on actions: **when it is impossible to influence a difficult situation in reality, defenses are created** to enable individuals to cope.

the impossibility to act blocks the thought process

Such a situation cannot be resolved by acting solely on defenses: the possibility of beginning to take concrete action on difficult situations is necessary for redeveloping critical and creative thinking. The abilities to reflect, discuss, and take action are closely linked, and when one of these becomes blocked, the others will eventually too.

8.3.3 Withdrawal

Some individuals never find in their work the positive resonance with their personality and motivations described earlier. In this case, it is possible to witness a subjective retreat, a sense of detachment from work, since "real life" is elsewhere. Some of these individuals compensate for occupational withdrawal by investing a great deal of time and effort in sports or associations but, on the whole, putting "real life" on hold during work hours (*i.e.* most of an individual's waking hours) rarely leads to a satisfying balance in personal and family life. Withdrawal makes individuals psychologically and socially vulnerable.

What's more, this loss of professional commitment can affect the performance of the individuals affected, compared to other more motivated employees. Withdrawal stances are of course actively discouraged by the organization and pressure will be exerted on these individuals, who will then often find themselves in a difficult position.

8.3.4 Depression

Depression threatens individuals who have shown great commitment to their work but who, as a result of technical or organizational changes, no longer manage, no matter what they do, to find a way to perform their work to a standard that can be evaluated positively by themselves, their "customers", their colleagues, their superiors and their loved ones. In a group of employees subjected to the same constraints, some will be in greater danger than others because of their personality.

Psychological harassment

Since the late 1990s, "psychological harassment" has become a frequent "explanation" for the difficulties faced by an employee: the cause of his unhappiness might be found in the aggressive attitude of some other person – usually his line manager. This type of scenario leads to the employee leaving and/or action (including legal) being taken against the "harasser".

psychological harassment or conflicting rationales?

Occupational health literature shows that in reality, in a very high number of cases, placing the blame on the manager's personality is unjustified. Most often, issues related to the work organization lie behind the unhappiness of the employee. More precisely, the employee and the individual he is dealing with do not have the same idea of "a job well done": rather than a conflict between individuals, there is a conflict of interpretations with regards to the work objectives.

Being unable to perform one's job well

The feeling of not being able to do one's job well—no matter how much one tries—is indeed one of the main sources of mental health issues in the workplace.

After various attempts and as many failures, the individual gives up and depression sets in, accompanied by the generalizing explanations described earlier. For some individuals, the risk of a suicide attempt is very real. But where does this feeling of not being able to do quality work stem from?

Conflicting rationales

Example in a call center

In some call centers, the kind of quality that each customer service representative would like to offer is to provide a satisfactory answer to the requests of each customer. On some calls this can be done quickly, but on others it requires a long conversation. For management, however, quality is measured by statistics, such as the percentage of customers who received an answer quickly. The manager will therefore put pressure on the customer service representative to cut short lengthy conversations, in order to satisfy a statistically higher number of customers.

Such conflicts in rationale are very frequent in work situations. The notion of work well done differs depending on the point of view.

Differences in points of view

Some might consider a job is well done because it was highly productive, even though liberties were taken with the safety rules. Will an operator who rushed to close off a leaking valve without taking his breathing apparatus be congratulated or reprimanded by his superiors?

The different rationales in play are legitimate, since they are necessary to the company's operations. But the opportunity must exist to explain and discuss their different criteria and for an unambiguous decision to be made.

being able to express one's notion of a job well done

What situations interpreted as "psychological harassment" often conceal are situations where one viewpoint crushes the other. Whether consciously or unconsciously, employees are bearers of information and criteria for work well done which are important to them. But the organization does not allow them to defend these criteria in the face of other viewpoints. Besides,

often they are not psychologically fit to analyze and express this in relation to specific situations. Explaining with generalizations such as "the boss just keeps..." leads to interpreting the situation as psychological harassment, but this approach will not allow action to be taken on the organization itself.

8.3.5 The organization's response

Whether the issue is tackled from the perspective of the psychological attitude to stress or that of subjective mobilization, we arrive at similar conclusions: to remedy the unhappiness of employees and their possible detachment from their work, their **collective capacities to analyze, discuss, and take action on situations must be restored**.

Specialized skills are generally necessary to help company employees with this process.

8.4 Recognition, fuel for subjective mobilization

An individual's level of motivation for his work depends on how much **recognition** others (superiors, customers, colleagues, loved ones) give to his contribution. Everyone expects to be told or shown that they contribute to delivering **quality work**.

recognition from customers, peers, superiors

An employee expects his customers (whoever they are) to mention the fact that he took good care of their specific needs, or in other words that the service was above standard.

From his colleagues and occupational group, he expects recognition of the fact that he is a true professional, that he respects the common rules of the occupation and contributes to promoting them.

Through his superiors, an employee expects the company to recognize his professional commitment. Of course, this recognition is in part salary-based, but many other aspects come into play. A manager who shows that he knows a result was achieved thanks to great effort on the part of his employees and who analysis with them what happened in order to improve the process for the future, gives recognition for the reality of the work performed. A manager who "doesn't want to know about it" deprives employees of this recognition.

The same applies for the presence—or absence—of discussions on the elaboration of procedures, on the design or choice of work tools, on the conflicting viewpoints that may arise, on the elaboration of training programmes, on the annual appraisal, *etc.*

> Any involvement from management that leads to the possibility of discussing the conditions for implementing the company's goals, the difficulties that are encountered or likely, the measures to be taken and the developments to consider, is a form of recognition of the specific contribution of employees.

This is true even when the reason for the manager's involvement is to indicate to the employee that something was not done correctly.

For some company employees, and especially managers, the constraints to take into account are so complex that they may allow themselves more time to formulate a quality response by taking some work home. Beyond a certain stage, it is their loved ones who will manifest a rejection of this strategy. The employee in question may then see no suitable solution and his health may be jeopardized.

The organization of the company cannot single-handedly provide all of the forms of recognition that employees need to maintain their health and their motivation at work. But it plays a crucial role in ensuring that management deals with this issue.

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9

The organization: its strengths and weaknesses

The organizational aspect of industrial safety came to the fore in the analysis of the Challenger space shuttle accident. It is now clear that the characteristics of an organization can increase or reduce the risks of industrial accidents.

This chapter presents the various elements that make up an organization, the role of management in the life of the organization, the signals that can indicate organizational problems, and the known characteristics of organizations that are most conducive to industrial safety.

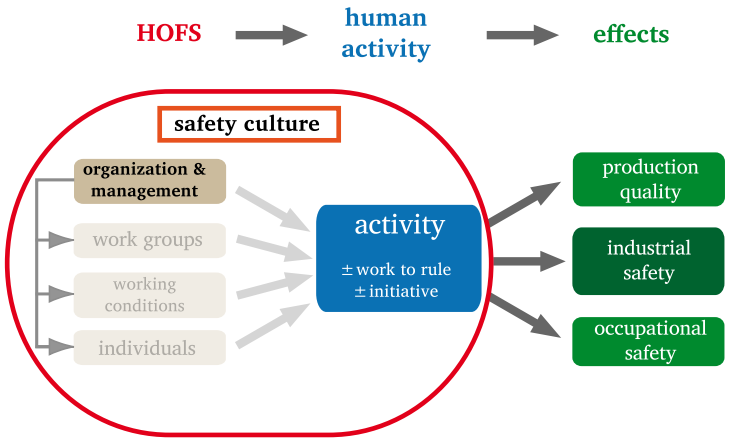


Figure 9.1 – *The subject of this chapter*

9.1 The different aspects of the organization

The notion of organization is often likened to an **organizational chart**, which defines the roles and responsibilities of each person within the company. This image is too simplistic to allow for HOFS to be taken into account within the company. Even the comparison with a complicated **watch movement** is misleading (see Figure 9.2): the organization is not simply a sophisticated transmission and amplification system.

Figure 9.2 – *Oversimplified images of the organization*

every organization has multiple facets

Every organization is a complex system with **several driving forces**. An organization is always inextricably composed of a **structure**, which defines its framework, of a set of **interactions** between the individuals and the groups that sustain it, and of **cultures** and collective identities that exist within it. Every organization also exists within a larger **environment** (the economic, legal, regulatory and social context) which exerts a strong influence upon it.

9.1.1 Organizational structure

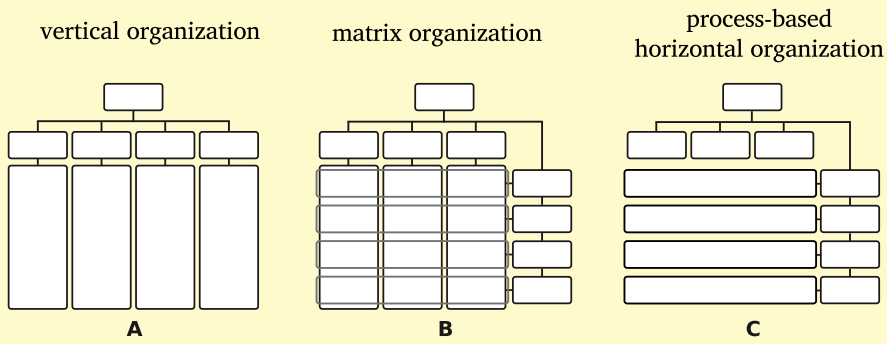
the structure is a set of constraints

The **organizational structure** is what we can plan and decide to put in place: the headcounts of the various departments, the organizational chart, the definition of the production process, the various types of formal rules and procedures, the information system, *etc.* The structure also has a material dimension: the layout of buildings defines proximities and architectural barriers; restricting access to specific areas or data enables or prevents certain collaborations, and so on.

The organizational structure reflects the operating mode chosen by the company to face the various challenges of its socio-economic environment, to meet the demands of the various stakeholders that assess it, and to react to variations in context.

Different organizational models

The different organizational models give a good indication of the options that are favoured. Thus a vertical model (model A) favours an organization divided into different functional departments, where the coordination is centralized within a powerful management structure that applies a top-down planning strategy. This type of structure values the reduction of uncertainties and the coordination and routinization of work, mainly through rules and a hierarchy. It is suited to an environment that is quite stable, in which priority is given to the mass production of a clearly defined product.



To the opposite extreme, a horizontal organization (model C) favours the division of work based on customer-focused processes or according to projects. The goal of this type of transverse structure is to encourage responsiveness and innovation in a competitive and fast-changing environment.

The strength of each model is the weakness of the other: a vertical structure is inflexible and struggles to adapt quickly to changes in market conditions; the horizontal structure is more flexible, but coordinating everyone involved is often difficult since there is no well-established hierarchy. Hence the advent of a more recent third model, a matrix structure (model B), with a dual line of authority: a horizontal reporting line in charge of coordinating the project/process and a vertical line of authority in charge of managing the teams.

The organizational structure determines a framework of constraints that have an impact on all employees. But the organization only thrives through the activity of the individuals and groups that compose it.

9.1.2 Relationships and interactions

If individuals' activity and interactions are very different from what is planned in the organizational structure, the organization is weakened. The structure can only last in the long term if it is supported by the daily activity of the employees of the organization, so it must also be reasonably compatible with the other determining factors of this activity.

Dual management in matrix organization structures

As previously stated, matrix organization structures rely on a dual management system (vertical and horizontal) in order to achieve both responsiveness and coordination. Since power is not evenly distributed, this highly fashionable organizational model can also generate tensions. Imagine a situation where someone is the official head of a team, but where the members of this team constantly refer to another manager to obtain resources or arbitrate conflicts: in this type of situation, the actions of the individuals involved do not support the organizational structure, but rather damage it.

necessary compatibility between structure and activity

To understand an organization, it is therefore necessary to identify the nature of the **relationships**—especially in terms of cooperation and/or conflict—that exist between employees. These relationships not only reveal the personality of each person: they reflect the **strategies** of each individual or social group (unconscious for the most part), directed partly at achieving **common goals** and partly at obtaining forms of **power** and **autonomy**.

These strategies are structured first and foremost around the **major challenges** the company must face and the forms of **uncertainty** that exist in every domain. The table below (see Table 9.1) presents a few examples.

Challenges	Uncertainties	Examples of groups affected
Market	Successful launch of a product Changes in market prices	Marketing Sales department
Quality	Variations in the quality of a product	Quality department Production
Efficient and reliable facilities	Technological uncertainty	Engineering, R&D, production, maintenance
Availability of facilities	Failures, unanticipated unknowns	Maintenance, production
Brand image **Public opinion**	Media, boycotts	Senior management Communications
Industrial safety	Operating authorization Incidents, accidents	Senior management, safety management, production, external communications
Social climate	Absenteeism, recruitment difficulties, strikes	HR department, management, trade unions, employee representative bodies, trade groups

Table 9.1 – *A few examples of uncertainties that create pockets of power within the organization.*

Employee strategies also depend on the resources at their disposal to face the company's challenges.

Any person or group in possession of the resources necessary to reduce uncertainty holds a certain power; this is not necessarily reflected in the organizational chart.

One important resource for gaining power lies, for example, in the knowledge held by the employees.

The power of the expert

On the shop floor, it is possible for the maintenance technician to wield more power than the foreman. This can result in very tense relations between these two people, even though the foreman usually has official authority. This situation is often explained by the fact that the main source of uncertainty in the workshop stems from mechanical failures which could impact production. And the maintenance technician is the only one with the expertise required to repair the failure; he therefore holds the resource that is most essential to reducing uncertainty in the workshop, which explains his power.

different sources of power

Other resources such as having control over the rules, or one's position within the organization (for example: being a mandatory intermediary between two departments) are sources of power. So is the control of information: the employees of the quality department, for example, are not the only ones to hold information about what influences product quality. The way these other employees interact with the quality department will be decisive in obtaining a good result.

Understanding an organization cannot be limited to only understanding its structure and the interactions that develop within it at a given time. The history of the organization generates collective cultures and identities that must be taken into account.

9.1.3 Culture and collective identities

Culture

Definition

In its broadest sense, *culture* can today be considered as the entire set of distinctive spiritual, material, intellectual and emotional traits that characterize a society or a social group. Besides art and literature, it encompasses lifestyles, fundamental human rights, value systems, traditions and beliefs (UNESCO definition).

Many of the elements of this definition can be applied to the culture of a company, or to that of a professional group.

The collective culture of a social group is the result of the **repeated experience of convergent practices** in categories of given situations. For example, a child who repeatedly experiences ways of celebrating Christmas and birthdays will have these cultural elements impressed upon him and will reproduce them, at least in part, during his lifetime. In the same way, the repeated experience of the way in which an organization handles a quality-related issue contributes to structuring an employee's quality culture.

repeating practices forges culture

This *repeated experience* aspect means that simply deciding to change the culture is not sufficient to make the change happen quickly. It is the repetition of new, convergent practices (those of management in particular) that will forge the new culture, and not the announcement of a change in direction. But the earlier cultures have a half-life: although the contextual elements that gave rise to them disappear, the cultures themselves continue to exist for a long time. For example, in the case of a merger of two companies, the culture of each company continues to coexist with the culture of the new group, losing ground progressively. The culture of a plant is thus frequently composed of different **cultural strata** that coexist and have various influences on the behaviour of employees.

sharing values is a source of cohesion

There are national cultures, industrial group cultures, plant-level cultures, department cultures and professional group cultures. These different cultures also carry values, some convergent and others distinct. The **shared values** within an organization are a very potent source of cohesion that can serve as a foundation when handling inevitable conflicts in rationale between the various challenges the company must deal with. In contrast, organizations in which few values are shared between the various social groups are significantly weakened.

There are two aspects to the **identity** of a professional group:

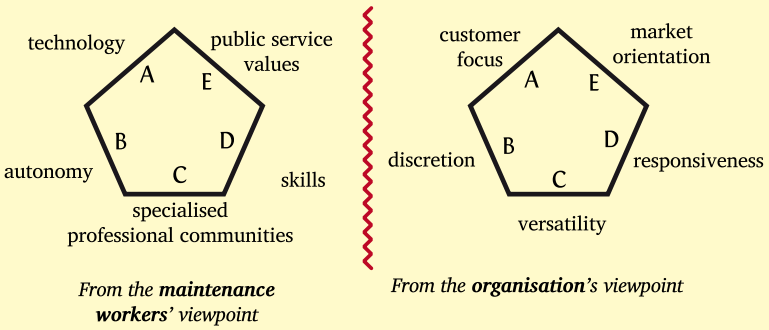
- the feeling of remaining unchanged over time, or in other words the perception of continuity in the bonds that unite the members of the group;
- the feeling of being completely different from all others.

Occupation-specific knowledge is one of the aspects that make up the culture of a group: as described in Chapter 6, occupational rules are different from formal rules, but they bring an essential contribution to production and safety. As the context changes, the organizational structure and professional groups will change according to distinct processes. When there is a significant gap between the identity of an occupation as perceived by the group and the criteria defined by the organizational structure, severe tensions can ensue.

Maintenance work from the point of view of technicians and that of the organization

Following a reorganization, a telecommunications company redefined the job role of the maintenance technicians who work on the lines and cables that connect customers. A brochure and an internal communications campaign emphasized the various facets of this new job role: the organization now asked its technicians to sell additional services to the customers they visited, to follow a schedule set by a remote platform in charge of coordinating their service calls according to the importance of the customers (a market-oriented approach) and, at the same time, to improve their responsiveness and be able to repair many different types of equipment. Yet this new way of doing things clashed in every way with the occupational culture of the technicians who, in contrast, valued the technical nature of their work, their autonomy (freedom to choose the order of service calls), the equal treatment of customers (public service approach), technical expertise and "beautifully done work", while differentiating between technicians in charge of lines and those in charge of cables.

gap between organizational definition and job culture: risk of tensions



*From the **maintenance workers'** viewpoint*

*From the **organisation's** viewpoint*

This level of tension between the official version of the maintenance technicians' job and that of the technicians can have impacts on safety. Indeed, the technicians saw the divergence as a blatant lack of recognition of their work, which generated a deep sense of detachment that in turn caused a sharp rise in traffic accidents.

9.1.4 The environment

Beyond how it functions internally, the company must thrive and develop in a changing context comprising many sources of judgment of the way it operates and its results:

- shareholders and the stock market;
- the geopolitical environment;
- customers and, more generally, the market;
- the legislator, government administrations, regulatory authorities (for example the obligation of implementing a SMS, ensuring it is used and documenting its activity);
- the general public, local residents;
- internally, the employees and their representatives.

To achieve its objectives, the company has a vertical chain of command but also a number of functional departments, each with its own way of doing things, and these must all be made compatible. (Figure 9.3 shows a simplified view of this; the functional departments themselves intervene at different management levels. The same structure can be applied to the various levels.) These departments adapt the objectives set by senior management to their own area (in terms of safety, for example), and organize the reporting of information. The integration of each specialized approach occurs at the level of senior management, which defines the goals, and at the level of the line departments.

In conclusion, the organization must not only deal with situations it was able to anticipate, but also with contingencies that happen unexpectedly. The organization must therefore both prepare its response to foreseeable situations and constantly ensure that sufficient resources and slack are available to deal with situations which were not anticipated. To ensure this, it has various internal driving forces at its disposal (structure, relationships, cultures) that are interconnected and whose interactions can either be powerful **cohesive forces** or influences that are likely to damage it. For example, internal job-mobility rules can encourage or hinder

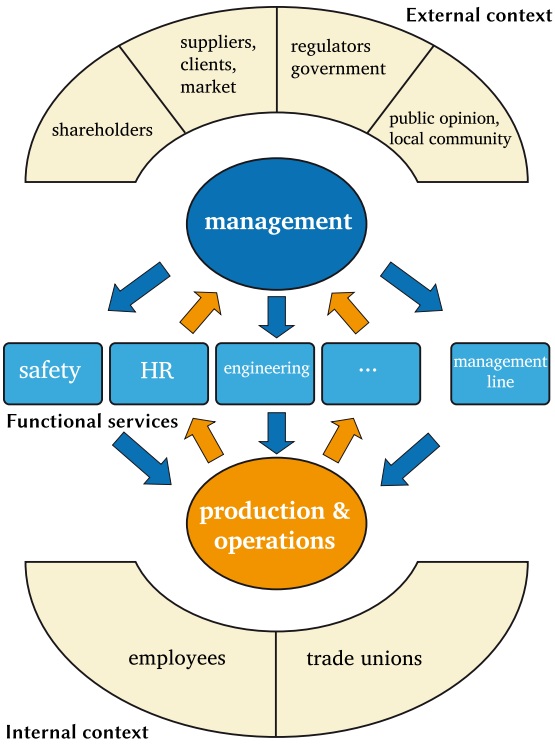


Figure 9.3 – *The influence of context*

interactions and the development of a common culture within a workshop, depending on whether the staff turnover cycles on a specific shop-floor are short or long. Informal relationships between departments can strengthen a new organization by compensating for its deficiencies, or they can weaken it by creating a parallel operating mode. Likewise, groups that are strong and structured around an occupational culture encourage cooperation within them, but can on the other hand generate confrontations between the various departments (maintenance and production, for example).

Thus, the organization reveals itself to be a complex and dynamic socio-technical system, that we can define as the process which allows the cohabitation of objectives and priorities which would not fit together easily without help.

9.2 The role of management in the organization

9.2.1 Adjustments in the organization

Faced with the different challenges of the organization, the primary **role of management** is to arbitrate based on an up to date appraisal of the situation, and decide on compromises which are reasonably acceptable to the various parties which are able to produce positive or negative impacts on the company.

There are several sources of rules (formal rules, occupational rules) and several types of knowledge and power within the organization. For everything to run smoothly, two types of adjustments are necessary:

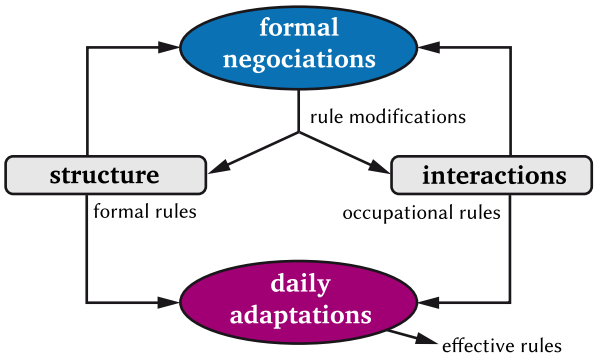


Figure 9.4 – *Adjustments in the organization*

On the one hand, many adjustments take place daily between operators or teams and their management. When certain formal rules contradict one another or the occupational rules, when the formal rules are too incomplete to allow the achievement of objectives, when objectives and resources seem incompatible, a discussion takes place while the work is being carried out, in order to reach an agreement on the course of action. The formal rules are not changed, but their interpretation is clarified or exceptions decided upon, leading to the definition of a new **effective rule**. These daily adjustments occur in all professional categories within the company. They allow the company to run effectively, but can be costly for employees, who are unsure about the applicability of rules, and for management, which must manage these exceptions.

daily adjustments

Another type of adjustment is called for if exceptions are increasing in number or if an external event (such as a new regulation) imposes it: the redefinition of formal rules. This involves formally integrating into the structure what until now was only local adaptations in daily work practices. A formal discussion then takes place, involving members of management and representatives of the employees and/or departments in question. The result of this is an **agreement to modify the formal rules** in order to improve their compatibility with real work situations.

rule adaptation

Even so, reaching an agreement on new rules does not necessarily imply a decrease in daily adjustments and their human cost. If people negotiating are not sufficiently familiar with reality in the field, the new framework will be defined based on their vision of reality, without sufficient information about what actually causes problems on a daily basis. In this case, new tensions may arise when the operations are carried out. Renegotiation of the formal rules must therefore always be supported by sound knowledge of the shop floor.

human cost and possible tensions

9.2.2 Being a manager: defining the framework and making it work

Management (line managers, department and site managers) plays a major role in these adjustments which enable the organization to thrive:

- managers contribute to the preliminary definition of the structure and in particular the formal rules (they “define the framework”);
- they make the necessary daily adjustments between the formal rules and other sources of knowledge and rules, in particular the various occupations (they “make it work”);
- they take part in the periodic renegotiation of the formal rules when this proves necessary.

This contribution from managers, which consists in rendering the various “driving forces” of the organization compatible (formal rules, knowledge, occupational cultures, *etc.*), is very much more than simply transmitting information:

- the manager is responsible for the two-way **translation** of the information he communicates;
- he initiates local **projects** that reflect his global understanding of the various stakes;
- he reports **summarized information** to his own superiors;

- he **negotiates** the relationship between objectives and resources;
- he **prioritizes** and ensures the **compatibility** of the rules produced by the structure;
- he **anticipates** contradictions between the different sources of rules and knowledge; he **monitors** and decides on the conditions for their application;
- he participates in the **performance evaluation** of workers, which should also include an evaluation of the difficulties they face when performing their work.

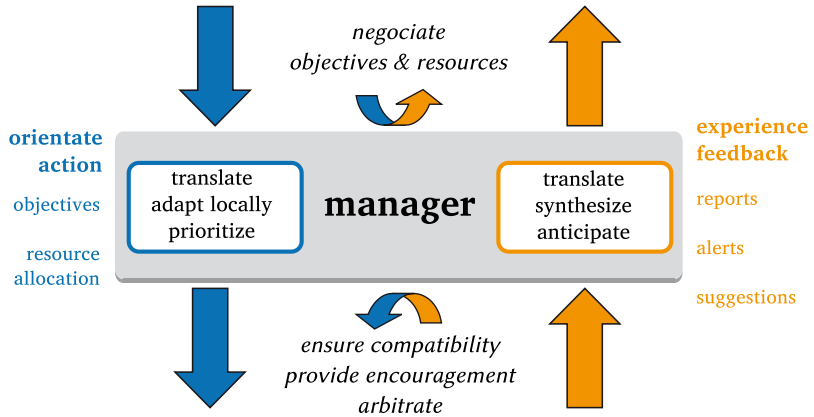
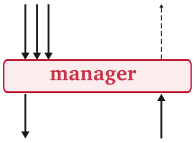
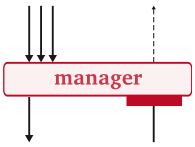


Figure 9.5 – *The role of the manager*



The fact that managers are positioned at the point where the upstream and downstream flows of the organization meet (see figure on the left) is not without its share of tensions:

- information and instructions coming from the different departments of the head office can be more or less contradictory ("priorities" abound), or are sometimes obscure;
- information stemming from the reality of the team or department is not easily compatible with the objectives and resources set by senior management;
- it is not always easy for the manager to report the contradictions encountered to his own superiors, especially when the organization values the fact that "a good manager is one with no problems".



a manager who protects himself shifts the problem

When a manager finds himself caught between contradictory flows of information, one way he might protect himself is to limit the information from the field that is reported back up the chain of command (see figure on the left).

The manager then continues to communicate information and directives from senior management, but no longer reports information being fed back from the reality in the field. This protection is sometimes the result of a conscious decision, but can also be a subconscious defense mechanism (see Chapter 8): an extremely busy manager who is constantly in meetings or on business trips is no longer "disturbed" by information from the field. This defense protects his health, but shifts the problem to the next level in the chain of command.

9.2.3 Negotiation work

The situation for employee representatives is very similar to that of managers. They too must handle the collation, translation and harmonization of information flowing downwards from the centers of power of their organization and information flowing upwards from the various employee groups. They too take part in negotiating the rules of the organization. They too can play a major role in providing management with feedback on the organizational problems or blockages that are likely to affect safety.

As is the case for managers, the legitimacy of their function or responsibilities does not automatically imply precise knowledge of all the situations they are called on to handle: the ways in which they inform themselves on the realities employees face in their jobs—or on the contrary, how they protect themselves from these realities—play a crucial role.

Some negotiations within the company have a direct bearing on industrial safety (headcounts, reorganizations). Others can have more direct consequences in terms of employee motivation

(salary negotiations). The quality of the interactions between trade unions and management is one element of industrial safety.

industrial safety *also* depends on good interactions between trade unions and management

Negotiations are genuinely hard work. They require a lot of personal investment on the part of the negotiators, who have to interact with the other party and also be accountable to their principals, who have less information than they do to assess the realistic nature of the demands or proposals.

The organization of the negotiations influences both their human cost and their results. Briefing sessions, agenda planning, and session adjournments allow negotiators better to interact with their principals. Agreement on shared values (industrial safety, for example), on common concepts (in terms of HOFS, for example) and on work methods (such as the analysis of critical tasks) facilitates the work of the negotiators representing the various parties.

9.2.4 Tensions and crises within the organization

When the various "driving forces" of the organization push in opposite directions, this results in tensions and crises that can jeopardize industrial safety. There are a number of classic symptoms of these problems. If they are identified while they are still "weak signals", an appropriate solution can be found to ensure the situation doesn't develop into a dangerous crisis.

Here are some examples of these symptoms:

- a deterioration of the work atmosphere, the spreading of rumours internally and externally, acts of violence between employees or employees and their superiors, questioning the behaviour of managers;
- an increasing number of minor accidents (falls, trips and spills, minor cuts);
- a rise in absenteeism, long-term sick leave (back pain, cardiovascular problems, depression, *etc.*), suicide attempts or rumours of them;
- an increase in the number of resignations or requests for transfer, high turnover (including of contractors), recruitment difficulties;
- a rise in the number of strikes based on poorly specified demands.

The above symptoms do not apply only to high-risk industries, but it is there that they may have a critical impact.

- Holding back information, giving insufficient information at shift changes, collaboration problems between teams, no information provided on production or maintenance ("nothing to report" symptom), ignoring or sidelining whistle-blowers, circulating false information ("trial balloons"). The entire experience feedback process is then threatened;
- Withdrawn attitudes and the absence of volunteers for training or work groups, which make it difficult for the organization to adapt to changes in its environment;
- Acts of sabotage (with or without a strong impact) on the production facilities and safety devices.

symptoms are often invisible to management

Many of these signals should raise a flag for on-site managers, but are not directly accessible to them. Several information channels must be activated for the warnings to be heeded in time: the chain of command, the employee representative bodies, the trade unions, HR, the occupational health department, the staff welfare department.

9.3 Organizations that jeopardize or promote safety

Analysis of several major industrial accidents has revealed organizational factors that are frequently present in their genesis.

9.3.1 Inappropriate facilities, tense relationships

Amongst the structural problems identified in these accidents, we note for example:

- an exclusive focus on certain issues and considerations (financial, for example) and the disregard of employees with other considerations (such as safety);

- pressure to achieve high productivity, which forces the system outside of the operating zone for which it was designed;
- no reassessment of operating assumptions during changes in the use of facilities;
- design or modification processes are centralized or externalized, but there is no interaction with those responsible for operations locally;
- failures on the part of inspection authorities or regulators;
- artificial messages from management that are drafted by "spin doctors" and make no sense to operators and local managers;
- conflicting priorities from different central services, with no harmonization by site management;
- organizations that are so complex or change so often that employees no longer know how to act with regards to them, nor whom to turn to for answers;
- setting objectives that are out of phase with the allocation of resources for a particular sector of the system ("I don't want to know" type of organization);
- an increase in quality assurance processes, with no allocation of additional time resources, leading to a decrease in the actual time available to carry out operational tasks and a loss of precision in actions relating to safety.
- types of subcontracting that do not guarantee a two-way exchange of information and skills;
- forcing employees or teams to compete against one other, which leads to a loss of cooperation;
- processes for evaluating people, teams or establishments based on criteria that are not common to all;
- tense relationships between the managers and the operators in their teams;
- lack of cohesion in the work groups, weak team spirit.

9.3.2 Success factors

In the same way, factors that contribute to making organizations "highly reliable[1]" have been identified.

- **Centralization and decentralization**
  flexibility
  High Reliability Organizations (HRO) have the capacity to function either in a centralized mode or in a decentralized mode, depending on the circumstances. For example, certain crises are better managed in a centralized mode (coordination with the authorities) and others in a decentralized mode (when communications are cut off, for example, due to a storm or flood).
  This flexibility requires the decentralization of power, competencies and technical resources. It also requires the existence of rules for switching from one operating mode to another, as well as regular practice in doing so.
- **Agreement on goals**
  safety objectives are present everywhere, every day
  In High Reliability Organizations, certain goals—particularly those related to industrial safety—are shared by everyone in the company. A strong safety culture (see Chapter 10) results from the fact that upper and middle management behaviour always takes safety considerations into account when making the decisions and compromises needed to ensure daily production.
- **Awareness that failure is possible**
  constant reassessment
  High Reliability Organizations develop awareness of their complexity and of the fact that a major accident is always possible in spite of all precautions. They allow themselves no self-congratulatory speeches, empty words, or any approximation where safety is concerned. The assumptions and processes on which safety is based are regularly reassessed. There are numerous feedback channels and warnings are always dealt with. The right and duty to halt an operation when the conditions are questionable are demonstrated in practice.

[1] High Reliability Organizations, or HRO, are organizations that have significantly fewer accidents than the average.

- **Sensitivity to operations**
  The organization is aware that carrying out operations is not simply a matter of applying pre-defined rules, but that it involves detection and local management of variabilities linked to the specific operating conditions. The possibility that things might not go as planned is present, and resources are available (the solutions possible in real time are clearly identified). Managers and experts agree to being "disturbed" when an operator is in a situation of uncertainty.

  availability of resources

- **Aiming for resilience**
  The organization is aware of the necessity of combining regulated safety (based on the knowledge of experts) and managed safety (based on the knowledge of the operators, groups and local managers). Managers are responsible for ensuring that these two contributions work effectively together (see Chapter 10).

  regulated safety
  managed safety

- **Double-checking**
  There is widespread double-checking between employees, through both formal measures (dual signatures, for example) and cooperation within the work groups. Work preparation and post-job verification tasks are valued and the necessary time is allocated.

- **Training and practice**
  All employees involved in operations are given regular training and practice role-playing on incidents or simulated accidents. The results of these sessions are used, if necessary, to change the equipment or the organization.

9.3.3 No unique model

Every organization is a bridge between the technical processes and the socio-cultural context. We therefore cannot reason in terms of there being "one best way" for the organization: the same technical process may call for different ways of organizing in different social environments.

It is dangerous to assume that an organization, methods, or tools that work well in a given context will be as effective for the same process placed in a different context.

Headcount ratios

For example, using departmental headcount ratios for international comparisons can be misleading: a maintenance department in a country where the climate constantly deteriorates facilities cannot be staffed in the same way as it is in a country with a temperate climate, even if the process is identical.

Each organizational structure presents strengths and weaknesses that must be identified and managed.

Different ways of organizing maintenance outages

Mathilde Bourrier has studied the annual maintenance shutdowns in several nuclear power plants around the world.

In one case (A), preparation time is relatively short and engineering staff are not readily available in real time. The difficulties encountered are reported, but solutions are found locally by ingenious and motivated operators and managers.

In another case (B), considerable resources are allocated to preparation and on-site assistance. Every difficulty is handled by experts who are constantly available. Any initiative on the part of the operators is forbidden.

Organization (A) is highly adaptable and has a good capacity to deal with unexpected events, but generates pockets of underground information and little traceability of the reality of the operations. Organization (B) is very explicit and constantly improves its processes, but it is costly and leads to a certain apathy on the part of the operators, which limits the ability to deal with emergencies.

9.3.4 Reviewing an organization

Any manager taking on a new job is well advised to perform a review of the organization he is joining. He can do this alone or call on a specialist.

An organizational review focuses on all of the aspects mentioned in §9.1: the structure, the groups, the relationships, the collective cultures and identities, the types of adaptation that take place within it, and any possible signs of problems that must be assessed in light of the organization's history.

- A **description of the context**: the organizational chart, the technical process, the internal and external rules that define how it operates. All of this is looked at from a historical perspective (recent and upcoming changes).
- An **identification of existing groups** (occupational groups, work groups, see Chapter 6), the characteristics of their members (gender, age, length of service, education and training, career path, collective health information), their history, the collective cultures and identities that dominate within them.
- An identification of the **inter-group relationships**: cooperation and conflict are not interpreted as being linked to personalities, but rather as the consequences of ploys between employees, resulting from power play, withholding information, controlling resources, and autonomy.
- The **daily adaptations**: difficulties applying rules, exceptions dealt with by local management.
- The **periodic formal adjustments**: procedures for modifying facilities, organizations, rules, industrial negotiations.
- Possible **signs of dysfunction** are looked for using indicators (see §9.2.4 and §9.3 above). The level of coherence between the general messages from management and the specific issues of the sector in question is assessed.

The next chapter (*cf.* Chapter 10) presents the means for evaluating and developing the safety culture.

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10

Safety culture

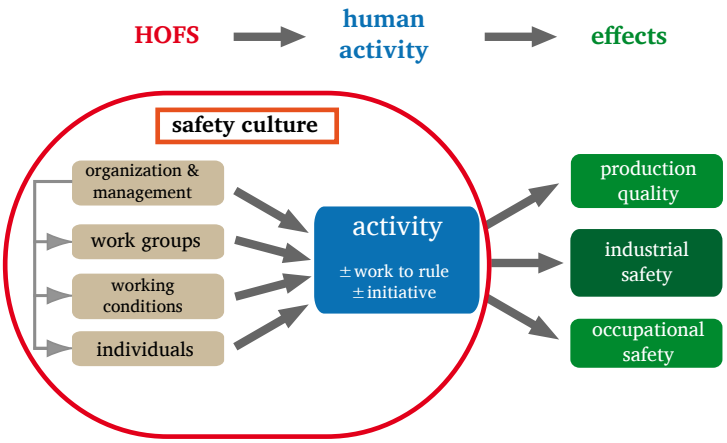

Figure 10.1 – *The subject of this chapter*

10.1 What does safety culture mean?

The term *safety culture* is relatively recent. It appeared around 25 years ago and was first defined and used in the nuclear industry, following the Chernobyl disaster that occurred in 1986. Indeed, the investigative committee attributed the fundamental cause of this accident to a company culture that was significantly lacking on all levels with regards to industrial safety:

- priority placed on production to the detriment of safety;
- tolerance shown to technical and procedural non-compliance in safety;
- deficiencies in safety-related training and communication;
- deteriorated work atmosphere, *etc.*

Safety culture

Definition

The term *safety culture* is used to designate that part of the company culture that relates to matters of safety in high-risk working environments.

More precisely, safety culture can be defined as *the set of practices that are developed and learned by the principal parties involved, to manage the risks of their occupation.*

10.1.1 The practices of employees create the safety culture of a company

These practices consist not only of ways of thinking about safety, but also of ways of acting with regards to it.

The influence of beliefs

Thus, the belief or conviction that all accidents can be avoided is a way of thinking that leads or predisposes one to actions such as wearing personal protective equipment or following safety instructions, in the hope of avoiding injury.

When it comes to ways of thinking about safety, we refer to things such as the **value** or the relative importance that employees place on safety (for example: Safety first!), the **beliefs, convictions and principles** that people develop regarding the "best ways" to tackle safety (obeying the established safety rules is the best way to avoid accidents, for example), and finally the **standards**, whether formal or informal, that are established in the sector as having to be applied in such and such a concrete situation (for example, the directive to wear hearing protection as soon as one enters a particular work area). These elements (values, beliefs, and standards) form a collective system that provides individuals with elements that frame their **understanding** and **action**, determining their usual behaviour in the various situations deemed as high-risk. Nevertheless, behaviour is not only influenced by values, beliefs and standards. It is also influenced by the **characteristics of the situations**.

The influence of context

Employees may have been convinced by management that following the safety rules is "the right way to work" and the best way to prevent accidents. But if regular staff shortages, due for instance to the non-replacement of absentees or a lack of backup at certain pivotal moments, leads to some rules being broken in order to maintain production, this situation will have more influence on modes of behaviour than convictions will.

As explained in Chapter 5, these situations put pressure on employees to act against their convictions, creating a mental state of "cognitive dissonance" that is unhealthy if it lasts. It also has a negative impact on the company's safety culture, since to eliminate this dissonance and re-establish coherence, individuals will end up convincing themselves that it is "normal" to circumvent the safety rules to ensure production. In order to avoid this weakening of the safety culture, some companies implement various practices to make it easier to report and handle situations that prevent employees from fully adhering to the company's safety policy.

10.1.2 Culture is built collectively

Management practices wrt. safety have a significant impact on the safety culture, because managers make the decisions that condition how risk is handled

Within a company, it is often said that "safety is everyone's business". Nevertheless, some people are more directly affected by issues of occupational or company safety, namely the management teams and the employees working in operations. These two major groups are generally the principal creators of the safety culture within an industrial company. Consequently, it is a mistake to narrow down safety culture problems to the behaviour of the operators alone. In fact, management practices with regards to safety often have a greater influence on the culture, because management has the authority and broader decision-making powers to influence the various factors at play in risk management. Furthermore, it is through the interactions between these two groups that the culture is built. It is the dynamics of these relationships that makes ways of thinking and acting become collective, in other words shared or reciprocal and accepted as "normal" by a large part of management and employees. Of course, it is not easy to create this unity, because both management and employees are complex groups, meaning they are made up of several levels and elements. Within management, for example, there are differences between the top-level management of a site and shop-floor management, between the staff managers and the line managers, *etc.* These differences also exist personnel in operations, for instance between production employees and those who take care of maintenance, between different generations during periods of intense staff turnover such as the current massive wave of compulsory retirements. That is why these challenges to the building of a common safety culture require the application of a truly cultural approach to managing industrial safety.

The breaching of safety procedures by operators can only become common practice and be considered "normal" if it is accepted by the work group and is tolerated by those who manage these operators.

But what is the purpose of the safety culture and what are its functions?

10.1.3 The functions of the safety culture

One function of the safety culture for the organization is to **influence its safety performance**. This effect is due to the fact that the culture is composed of the real practices of employees in terms of safety. Consequently, the effect of the culture on results can be more or less positive depending on the quality of the safety practices in use within the company.

When management succeeds in securing the adhesion of the majority of employees to common and convergent ways of thinking and acting with relation to safety, this leads to a second function of the culture: to provide the company with an **effective system for coordinating the parties involved**. This coordination system is complementary to the authority structure and essential to ensuring its effectiveness. *It is not possible to place a supervisor behind each operator to give instructions and check that they are being followed.* That is when the safety culture takes over from the authority structure, by regulating and informally checking individual behaviour to keep it within the limits allowed by the group or the organization, whichever the case may be.

The safety culture, an implicit "framework"

For example, an employee who maintains an important work practice that is considered by his peers to be dangerous or to go against the best practices of the occupation, will be pressured to mend his ways or risk being disapproved of, losing credibility, or being even more severely punished by the work group.

That is why it is so important for managers to truly integrate the work groups into the company's safety approach.

But the individual is also influenced by the pervading culture in his place of work.

Firstly, it allows him to develop and assert his **professional identity**.

The transfer of knowledge

Thus, a new recruit learns a great deal of his job skills from his peers and supervisor, who teach him and ensure that he acquires the key knowledge, know-how and interpersonal skills necessary to be accepted within the group and the company. In high-risk occupations, safety-related knowledge is an important part of this knowledge transfer.

Secondly, the individuals who adopt ways of thinking and acting that are considered "normal" by the group and within the organization, gain **social recognition** within the professional circle. This encourages them to continue down this path and thus contribute to maintaining this culture.

Finally, a strong safety culture contributes to the **mental health** of the individuals exposed to risk, by providing them with guidelines for perception and action and, above all, by making the behaviour of their co-workers relatively predictable.

A strong safety culture reduces stress in individuals exposed to hazards, because it reduces uncertainty by allowing them to anticipate the mental and behavioural processes that will "normally" be used by others to manage the risks in a given situation.

Nevertheless, the trade-off to this advantage can be that it facilitates certain types of errors such as those made in applying rules or those due to tunnel vision, both described in Chapter 7.

10.2 The diversity of safety cultures

Occasionally a company tries to copy the Safety Management System (SMS) of another organization or to adopt one sold by a consulting firm, but it will not be able to do this for its safety culture. That is because it is the long-term safety practices that the internal parties manage to build together that will make up their culture. This explains why it is possible to

see significant cultural differences from one company to another, and sometimes even within the same type of industry.

The following typology helps to understand this diversity by defining **four main types of safety culture**. It is based on the idea developed in the previous section, that where safety is concerned, the culture is a human construct built mainly by two major groups interacting together: management and operations personnel. And yet, even though both groups should in theory be involved in ensuring safety, in practice each of these groups can be more or less involved and active in the management of safety, and therefore in its cultural construction. The degrees (+/-) of involvement of these two groups are therefore the parameters used to establish the typology illustrated in figure 10.2.

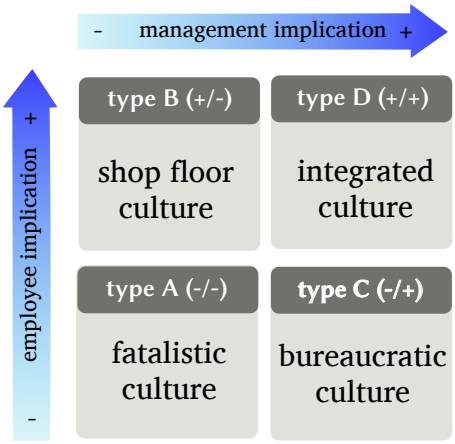

Figure 10.2 – *Types of safety culture*

The different cultures represented in figure 10.2 are **stereotypes**: simplified and static. In a real company setting, the safety culture is dynamic and evolving, and can therefore be a mix of different types of elements. Nevertheless, the typology is useful because it provides reference points for identifying the dominant characteristic of an actual culture. It is also useful for understanding the historical evolution of safety cultures and to see in which way they can develop in the future.

the bureaucratic culture dominates in high-risk industries

The safety culture that is currently the most dominant within large companies in high-risk industries is the **bureaucratic culture** (type C), whose main strengths and weaknesses will be discussed in the next section. But the typology puts forward another type where management is also very actively involved: the **integrated safety culture** (type D). This type will also be presented in a later section, because several companies have moved towards this type of culture over the last few decades and have managed to significantly improve their risk management performance.

As for the two types that correspond to a situation where management has little or no involvement in safety, the **fatalistic culture** (type A) and the **shop floor culture** (type B), they are still somewhat applicable for companies in high-risk industries. Here are a few illustrations of them.

10.3 The fatalistic safety culture

This culture is based on the belief that accidents that occur are caused by fate or a stroke of bad luck; in short, they are inevitable. Consequently, convinced that accidents will occur regardless, the common attitude amongst employees is to do nothing to avoid them. Historically, this type of culture was dominant in the West until the 17th century, due to a pervading religious culture that tended towards supernatural explanations for events in daily life. With the development of scientific knowledge and the industrial revolution, the fatalistic type of culture was edged out, but it lives on in certain business types and contexts. For example, in road transport, studies reveal that close to fifty per cent of drivers hold fatalistic beliefs that explain accidents as caused by misfortune or fate. In emerging or developing countries, it is common for the societal culture to be rather fatalistic in terms of preventing road or household accidents. This context presents difficult, though surmountable, challenges for companies that set up and operate high-risk industrial facilities in these countries.

10.4 The shop floor safety culture

Informal safety practices developed by workers to protect themselves from injury

This type of safety culture is characterized by little involvement from management, which considers that occupational accident prevention matters are the responsibility of the employees. Consequently, the employee group ends up taking the most responsibility for safety. Historically, this culture was predominant in the West during the pre-industrial period and at the beginning of the industrial era. During these periods, employers showed very little concern for work methods, which as a result were essentially developed by the workers themselves. In general, in high-risk occupations, several elements of these work methods were informal safety practices aimed at avoiding injury or protecting oneself against accidents. For example, one well-known safety practice developed by coal miners as early as the 17th century consisted in taking canaries down into the underground tunnels. The death of the canary alerted the miners to the risk of an explosion, and they were able to escape before it happened. The miners did not know the whole scientific explanation for the explosions (for example the nature of the gas build-ups, ignition, *etc.*), but they knew that the explosions were connected to a change in atmosphere in the tunnel which led to the swift death of the canaries.

As management took increasing control of the organization of work—which resulted, in the second half of the 19th century, in the development of the scientific organization of work, the standardization of tasks and methods, and Taylorism—the shop floor culture decreased in importance, including where safety was concerned, but without disappearing completely. In many industries, individuals working within a same occupational group, whether supervisors or operators, have informal shop floor practices that they apply in certain situations that are not covered or poorly covered by the formal safety rules. In maintenance-related occupations, the shop floor safety culture is still often predominant, in spite of the development of safety management systems.

10.5 The bureaucratic safety culture

This type of safety culture develops when management takes charge of industrial and occupational safety and plays such a dominant role in the elaboration and rollout of technical and procedural safety measures that operator involvement is often limited to the responsibility of applying these measures in their work.

Historically, the bureaucratic safety culture developed in the mining sector and progressively took over from the shop floor culture which nevertheless had a strong hold. This change first took place in England, which was the first country to experience an industrial revolution.

Towards a bureaucratic culture

The industrial revolution in England stimulated a phenomenal increase in the production volumes of coal mines during the entire 19th century. Unfortunately, the rate of fatal accidents increased proportionately. Thus, in the first half of the 19th century, gas explosions in underground tunnels caused some 35 000 deaths amongst miners. These repeated catastrophes, which were increasingly reported and denounced by the papers, and the presence of a progressive faction amongst mining employers, led the British government to legislate, regulate and undertake inspections in order to force mining companies to deal with safety issues, starting with the ventilation of underground mines. Once management took charge of safety, the rate of fatal accidents in coal mines dropped from 6‰ in 1850 to 1.3‰ in 1913. Since the beginning of the 21st century, this rate has stood at 0.2‰.

The mining industry is a good example, because it led the way for the emergence of the bureaucratic safety culture and it has the advantage of being documented over a very long period of time. But all high-risk industries with a substantial incidence of serious accidents, and even more so those that carry the risk of catastrophic accidents (such as the chemical and nuclear industries, oil and gas, civil aviation and high-speed transport, aeronautics, *etc.*) have evolved in the same direction. And the same **evolutionary factors** are often present: **external pressure** from the public and the government after catastrophes, but often also requests from **internal groups** (employers and trade unions), some of which demand state control in order to prevent competition taking precedence over safety, which is perceived as vital for the long-term viability of the industry.

10.5.1 Distinctive guiding principles

The bureaucratic safety culture is characterized by three main guiding principles whose implementation often brings a positive contribution to the development of safety:

1. **Ongoing efforts to improve safety performance**.
   Generally speaking, the drive constantly to improve performance is a strong point of the bureaucratic culture. Its application in the field of safety may not always go smoothly, but overall it is a mostly positive point.

   continuous improvement

   The case of mining outlined earlier illustrates a real improvement of the situation as far as fatal accidents are concerned. This would not have been possible without a **strong commitment to continuously improving results**.
   The major advantage of this cultural trait is that it promotes an attitude of constant reassessment and innovation, rather than one of satisfaction with the *status quo*. The two following points specifically apply to the resources.

2. **Technical aspects are highly valued**.
   It was the bureaucratic safety culture that led to the emergence and rapid development of **safety engineering**.

   The origins of safety engineering

   In the United States, the existence of the safety engineer profession (with training and a specialized degree as prerequisites) dates back to 1912 with the creation of the American Society of Safety Engineers.

   Until the 1970s this approach, centered on technical safety, greatly contributed to reducing industrial and occupational accidents because it developed **concepts** (such as the defense-in-depth concepts, redundancies, *etc.*) and **techniques** for **identifying** and **assessing** risks, and for **containing, reducing, or eliminating** hazards at their source. It instigated practices that have become references for the industry and also for many countries that have integrated them in their regulations. Thanks to this approach, financial investment in safety has also increased to a level that was totally unthinkable in the context of a shop floor culture, which explains the markedly superior effectiveness of the bureaucratic safety culture.

3. **A propensity to formalize safety and work management practices**.
   This is a more recent key characteristic of the bureaucratic culture. After having made safety progress in the technical elements of the organization's sociotechnical system, it was foreseeable that in order to continue improving risk management performance more focus would have to be placed on the social and human elements, and thus on the practices and behaviour of the employees. At the same time, from the 1970s onwards in the West there was a strong development of legislation and case law relating to the responsibilities of employers with regards to safety. The response to this development consisted in increasing the level of formalization of practices for safety management and work execution. These two aspects are generally accorded great importance and are decided upon by the company's senior management.

   increase in formalization

   Top management usually applies three main measures to formalize general safety management practices:

   - The first is the adoption of a **official safety policy** that is put on display. It is a brief document in which senior management lists the objectives and principles it is committed to implementing with regards to industrial and occupational safety.
   - The second consists in providing the company with a **Safety Management System** (SMS). An SMS is in fact a management handbook that states what safety management activities need to be performed, at what frequency, by whom, and how. It is a tool that aims to both develop new practices (such as visible leadership activities by top management) and standardize existing ones, particularly those of the chain of command, whose different levels are responsible for several elements of the SMS.
   - Finally, the third measure involves creating or empowering the **safety function** to advise senior management and the executive committee, train and help employees to become familiar with the standards of activities and methods for which they are responsible, organize and run internal and/or external audits of the SMS, *etc.*

Moreover, the formalization of safety aspects in operator work practices is often supported by the SMS.

The SMS helps to formalize critical tasks

Most Safety Management Systems recommend conducting a safety analysis of tasks—starting with those that are critical or important for safety—and establishing detailed safety procedures and instructions that are applicable to these tasks. These procedures also serve to train operators to perform their tasks in a more rigorous and standardized manner.

Likewise, task observation or safety visits by management are often recommended by the SMS: for the most part, they involve measuring how well the safety procedures are followed and discussing any implementation problems with the operators, in order to reduce the frequency and severity of accidents that result from not following procedures.

Though the formalization described above can sometimes have pernicious effects, it also often has positive effects.

10.5.2 The benefits

more sustained involvement from managers

Firstly, launching and implementing a process to formalize management practices requires senior management and top management to become a lot more actively and visibly involved in safety than they were previously. In other words, it requires them to exert a **stronger safety leadership** which, if maintained, is a positive force for changing the attitudes and practices of the rest of the management structure, and also of the employees.

creating a common frame of reference and management cohesion

What's more, rolling out an SMS, providing managers with appropriate training, constantly reviewing the individual performance of operations, and supporting the safety function, are all activities that contribute greatly to creating common ways of thinking (a frame of reference, for example) and acting with regards to safety. In short, these actions generate a much greater **cohesion and unity of action** by management than previously existed, which reduces the risk of failures of the safety management system.

shared work practices

As for the formalization of work processes for safety, it is very useful if it focuses on tasks that carry the risk of serious accidents and if it is done by involving the operators concerned. This approach makes it possible to develop **common perceptions of the risks** involved, as well as ways of working that are shared, and therefore predictable, and whose effectiveness in controlling risks is demonstrated. In short, it boosts team spirit, teamwork, and **collective vigilance** within work groups. It also helps improve the training of new operators, and facilitates their **learning** and their integration within the team.

Numerous observations tend to show that when it is implemented carefully, with consistency and perseverance, and social relations are generally cooperative, this bureaucratic safety culture manages to generate collaboration from the most implicated sections of management, and also from the operators. This contributes to a **substantial reduction in the accident rate**. But after a while, in many companies we note that improvement in the results **reaches a plateau** and unfortunately we sometimes also note the occurrence of serious or even **catastrophic accidents** in situations where the risks were thought to be under control. That is why it is also important to be aware that this culture can include certain limits, weaknesses or deviations. Here are a few of them.

10.5.3 The limits

The illusion of controlling risks

The accident at Esso's natural gas plant in Longford, Australia, unfortunately illustrates the limits of a bureaucratic safety management culture, which is effective for improving safety results, but overly focused on minor accidents.

The accident at Longford

On September 25th 1998, a major explosion occurred at the plant, followed by a fire. This led to the deaths of two operators, while eight others sustained serious injuries. Additionally, the accident led to shutting down the plant, which is the leading supplier of natural gas in the state of Victoria, thereby cutting off gas supply to a large customer base of companies and individuals for 20 days and causing them financial losses that generated requests for several hundreds of millions of dollars in compensation. The Royal Commission in charge of investigating the accident found the company to be fully responsible. Indeed, the Commission not only revealed problems with the design of the plant, but also the pernicious effect of a "safety culture" overly focused on improving the frequency rate of minor accidents through prevention, to the detriment of priority concern for identifying and managing the major risks associated with the facilities. In fact, for several years the plant had been applying a rigorous technical and behavioural management programme for occupational safety, which had allowed it to achieve a zero accident rate. But the investigation showed that efforts were much less intensive where industrial safety was concerned.

This case illustrates the dual phenomenon that quite commonly occurs in individuals, as well as in groups and organizations, namely the **illusion of control** and **optimism bias**.

Illusion of control, optimism bias

Definition

The illusion of control is the tendency to overestimate one's capacity to control events. Optimism bias is the tendency to underestimate the risks involved in events that may occur, and especially the seriousness of the potential consequences.

The bureaucratic safety culture encourages this dual phenomenon, because it places great importance on performance and therefore performance indicators. Where safety is concerned there is a **risk of simplification**, because the most widely used performance indicator is the incident rate. This rate, however, is composed almost solely of minor accidents, which are more frequent. Consequently, this indicator is not a true reflection of how well technological risks are managed, and few companies make the effort to create, use, monitor and react to indicators that are specific to managing these risks, which are less frequent but much more serious. There is therefore a genuine risk that once efforts to improve the incident rate seem to bear fruit and the indicator nears or even reaches the zero accident rate, management will start to believe that it has finally controlled the risk of accidents: it is the illusion of control. In turn, this illusion fuels optimism bias.

the illusion of control fuels optimism bias

Optimism bias

At the Longford plant, an incident similar to the one that provoked the explosion had occurred several weeks earlier and the operators had reported it to their supervisors. And yet the supervisors had played down the potential of the incident and had not informed senior management.

Another possible generator of optimism bias is the tendency to push back the limits of "manageable risk" because it is felt that the past performance of the SMS shows that it is increasingly robust and therefore capable of managing ever-greater risks. This tendency is seen when major maintenance work is carried out on equipment still in use, in order to reduce downtime and losses in production.

To reduce the probability of falling victim to this dual phenomenon, some companies that perform very well in risk management cultivate pessimism rather than giving in to the "natural" tendency towards optimism. They reward employees and managers who identify "cracks" in the system, and create performance indicators that are specific to technological risk management.

The normalization of deviance

This happens when the **breach of important safety rules** is not only widely known about, but also **tolerated and accepted** by peers and management as normal and acceptable behaviour given the circumstances.

The Challenger case

Analysis of the Challenger Space Shuttle accident in 1986 revealed that practically every person involved in the decision-making process for lift-off had failed to follow NASA's acceptable risk assessment procedure, and yet it was the result of this assessment that was to decide whether the launch would take place or not. The analysis also showed that this tendency to disregard this standard procedure, and several others, had started to develop strongly since the cutting of public funding for the shuttle programme by Congress several years earlier. As a consequence, the programme had to fund itself for the most part, through frequent commercial flights.

Various factors can contribute to the normalization of deviance. The Challenger example illustrates one of these: the **strong tension that exists between financial pressures and safety requirements**. Employees "manage" this tension by regularly deviating away from certain safety standards, because they believe (or are told) that strictly applying the rules would harm the financial performance of the company. In this type of scenario, top management can take action to prevent this deviation on the part of various employees. It can first of all take measures to ensure that they are informed of events where production pressure has a negative impact on safety, and then properly integrate safety into the management of priorities, and finally set up a protocol for managing exceptions or dispensations.

conflicting financial and safety imperatives

Another factor that contributes to rule-breaking becoming an accepted norm: when **formal safety rules** and procedures are **established without sufficient consultation with users**. This lack of dialogue often generates inapplicable procedures, and if there is no effective system in place for reporting the problems and correcting the initial flaws, it is likely that supervisors and operators will find it "normal" to break the rules in order to continue to get the work done. This factor also exists at the management level when the SMS is implemented without any real consultation of those affected. For example, supervisors may feel that the additional workload involved in performing the planned management activities is substantial, but they either cannot discuss this with the upper echelons or the latter simply reply that they must integrate safety management in their daily management of operations. Two types of deviance then frequently appear: either certain activities are simply not carried out if, for instance, there is little chance that completion of the task will be checked, or some are performed perfunctorily or to meet the imposed quota, in the case of monthly safety meetings, task observation, or planned inspections for example.

lack of consultation when establishing the rules

Deviations become the norm and are practically guaranteed to occur when **existing safety procedures** are not **regularly reviewed and updated**, since this widens the gap between the standards and the **changing reality** of work practices. Some companies also tend to over-depend on internal regulations and create so many procedures that it becomes impossible for an operator to learn them all and even more difficult to master them and apply them. Occasionally, the two problems are combined, creating a disorganized normative environment.

insufficient procedure review

accumulation of procedures

Finally, a **tense social climate** in the workshops is conducive to normalized or, at the very least, tolerated deviance. Studies show that, in such an atmosphere, supervisors will tend not to insist too much on employees strictly applying safety procedures that demand a lot of time or effort, to avoid aggravating them further and to maintain their cooperation in order to reach production objectives. In short, supervisors "choose the lesser of two evils". In other words, between a tolerated deviation that can increase the probability of an accident or an almost certain drop in production, supervisors choose the first part of the equation, which seems like a lesser evil because the accident is not certain.

social tensions

10.6 The integrated safety culture

This type of safety culture corresponds to a situation in which management continues to lead any safety-related actions, while developing various practices to encourage a strong involvement of operators in several safety management activities and in the rigorous application of the safety measures.

The limits and weaknesses of the bureaucratic safety culture, the growing complexity and dangerousness of certain sociotechnical systems, and the business strategies of certain companies, are all contextual factors that push more and more organizations to move towards an integrated safety culture. Though still limited in number, several studies have documented real cases of organizations with this type of culture, as well as their common practices.

To remain consistent with the definition given earlier, we can present some of these practices either from the perspective of management leadership, or that of operator involvement; these two perspectives make it possible to characterize the profile and approach of the two key groups that forge this culture.

10.6.1 Management's safety leadership

In the bureaucratic culture, management's safety leadership is generally of a top-down nature. This is true not only from managers down to operators, but also within the very management structure itself (from top management to middle management to first line management). In concrete terms, this means that the field teams (supervisors and operators) must work according to directives, rules, procedures and instructions which they have had little or no say in elaborating. This leadership style can be effective to quickly implement a change of approach in safety management within vertically structured organizations. Over a longer period, however, its weakness is that top and middle management deprive themselves of much knowledge about "sharp end' realities. Yet this knowledge is crucial for establishing and maintaining safety measures (technical or procedural) that are fully effective and thus ensuring a very high level of risk control, particularly in terms of technological risks.

An integrated safety culture avoids this weak point because its management style evolves towards safety leadership that is **both top-down and bottom-up**. We can characterize this top-down/bottom-up style of leadership by highlighting certain ways of thinking and acting that characterize it.

Basic beliefs and assumptions

Amongst the ways of thinking that are typical of the top-down/bottom-up leadership style, certain beliefs or convictions are important.

- One belief is that—in particular in the process industries—technology is never fully controlled and **unpleasant surprises are always possible**. This leads to practices that are both top-down and bottom-up in order to counteract any illusion of control and optimism bias, and maintain a high level of vigilance on the part of management and employees.

  Maintaining vigilance...

  ...by organizing the hunt for anomalies, incident reporting and analysis, presence in the field...

- this conviction leads to another: that risk management is never fully achieved and making the system reliable is in fact a **process of continuous improvement** that must be managed as such;

  Continuous progress approach

  Operational and safety standards or procedures are by definition imperfect and improvable, and management practices must support and encourage their continuous improvement.

- finally, one last conviction: collaboration is needed between the two groups (management and operators) for this continuous improvement process to produce the increases in safety and reliability required to prevent any serious industrial accidents and maybe even achieve zero accidents in the workplace. The groups involved have functions and knowledge that are different, and therefore limited, but complementary and essential to guaranteeing risk management. They therefore have a mutual interest in supporting this collaboration. Nonetheless, it is management that has the power to **change the rules of the game** in order to develop this collaboration, hence the importance of adopting a new style of leadership that is both top-down and bottom-up.

And the actions that result from them

Certain ways of acting result from these principles. Several of them are documented by a relatively high number of studies conducted in the United States and Canada, in Europe and

Asia-Pacific (Japan, Australia), and in different industries (the nuclear and chemical industries, civil aviation, petroleum and gas, petrochemicals, metallurgy, manufacturing of motor vehicles and other equipment, hospitals). These reveal that the safety leadership that is typically seen within an integrated culture generally involves managerial practices on the following points:

- the importance given to safety in the values and priorities of the company;

  Safety as a value

  Safety is mentioned amongst the three or four fundamental values, in other words those that intrinsically characterize the way business and work are conducted within the company. It can also be listed as an overriding priority, as is the case in this motto of a major Canadian company: "no work is important or urgent enough to justify it not being done safely".

- the exemplary nature of the leadership;

  Ensuring exemplarity in applying the safety policy, in ruling on situations where safety could be compromised by the pursuit of other objectives, in providing operators with the necessary means to follow the safety rules and procedures, in implementing measures that encourage staff members (managers or employees) to participate.

  Exemplary behaviour in top-down leadership is essential for building management **credibility**, which in turn is needed to convince operators to participate, and thus generate substantial bottom-up leadership.

  management credibility

  Example in the transport of fuel oil

  As an example, some companies that deliver domestic fuel oil by tanker in France have implemented a safety policy whereby they will refuse to deliver to a customer whose installation carries a high risk for the driver and which the customer refuses to modify in order to improve its safety.

- the implementation of mechanisms to encourage participation from operators;
  One highly valued strategy is to increase the presence of department and first line managers in the field, working alongside operators. This makes it possible to observe how operations and tasks are performed, to learn about any difficulties encountered, to encourage reporting of anomalies and any discrepancies in operations, to stimulate vigilance with regards to risks, to talk and listen to operators. The formulas that dictate their presence are variable (solo, duo, formal, informal, duration, frequency, *etc.*). Another popular approach encourages measures to increase risk detection and reporting. These measures vary (for example seeking out anomalies, campaigns to identify and evaluate targeted risks, detection of weak signals, *etc.*), but to achieve success they must be turned into a valued and organized activity that operators are trained for, and a process for monitoring feedback and communicating its results must be instigated. A third approach involves having the operators participate in the processes for continuous improvement of the rules and procedures for safety and operations: initial elaboration, validation, review. Here too, how the participation is organized is important (for example, work groups, targeted tasks and procedures, methods, *etc.*), but it must include ways to involve the groups or work groups affected, during the different phases of the process.

  increase the presence of management in the field

  encourage experience feedback

  encourage operator participation in elaborating the rules

- the implementation of measures to reinforce the rigorous application of rules and procedures.
  The purpose of having operators participate in the improvement of rules and procedures is not only to make them **easier to apply**, but also to **encourage their adoption by operators**. It increases their intrinsic motivation to apply the improvements, with support and backup from the team. Consequently, when the participative approach is well implemented, it contributes to **reinforcing rigorous rule application**. The same applies to the presence of management in the field, which was described earlier as a participative leadership practice, but which must also take the form of a quality-control exercise, en-

suring that procedures are being applied correctly (task observation, for instance). These verifications must be completed by a positive safety dialogue while encouraging certain improvements where applicable.

10.6.2 Operator involvement

Operator involvement in safety generally manifests itself in two ways: the fact of **complying** by obeying the established rules of safety, and the fact of **taking initiatives** with regards to one's own safety and that of others. In this way, at their own level, operators participate in the **dual approach of regulated safety and managed safety** that is present in all high-risk companies.

In the bureaucratic safety culture, these two forms of operator involvement are often dissociated. Management seeks compliance above all, is not interested in the operators' capacity for initiative, and even discourages it. As a consequence, there is very little initiative directed at management (for example, reporting, safety suggestions, participation in prevention activities). Management sometimes complains about this lack of participation, but in reality does very little to encourage it and organize it.

In the integrated safety culture, the aim of management is to stimulate and channel the operators' capacity for taking initiative, as leverage to increase their level of compliance with the rules. Indeed, through measures like those indicated earlier, management encourages operator participation (initiative) so that they can continuously improve the application and adoption of the rules in the field. Operators are thus more likely to comply with these rules that have become their own. In general, the operators are much more motivated by this approach than by that used in the bureaucratic culture. Indeed, it not only meets their need for safety in the workplace, but also other higher needs, such as recognition and appreciation from management, involvement in decisions, and the acquisition of new skills, all of which contribute to **job satisfaction** and cooperation in the workplace.

initiative reinforces compliance

That is why operator involvement in these two forms (compliance and initiative) is generally higher in an integrated safety culture than in a bureaucratic culture.

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11

The key HOFS points of the industrial safety policy

In this last chapter, we highlight the key points of a company's activities concerning Human and Organizational Factors of Industrial Safety. We describe the main challenges and areas of application of an HOFS policy.

The **methods and tools** that can be implemented for each of these areas of application, as well as the corresponding indicators, are or will be the subject of other guides published by the Institute for an Industrial Safety Culture or the Foundation for an Industrial Safety Culture.

11.1 Industrial safety, occupational safety: two complementary fields

Top management defines its safety objectives within two areas that are **complementary and interconnected**, yet distinct:

- the prevention of technological risks;
- the prevention of occupational accidents.

Indeed, in most countries there is a legal distinction between these two complementary areas, for which the regulatory authorities are not the same.

The evaluation of the safety policy of a site is based not only on the incident rate (Total Recordable Injury Rate[1] or Lost Time Injury and illness Rate[2]), but on a set of factors presented hereafter.

A demonstrated commitment to preventing technological risks can make it possible to obtain a strong consensus within the company.

11.2 Recognition of the human element

Top management:

- presents a vision of the human contribution to industrial safety;
- affirms the need to support it through appropriate technical and organizational conditions;
- identifies the responsibility of management in the area of industrial safety;
- and recognizes that no single level within the company has all the knowledge and information necessary to achieve safety.

It builds the industrial safety policy upon the balanced coordination of two approaches:

[1] TRIR: Total Recordable Injury Rate
[2] LTIR: Lost Time Injury and illness Rate

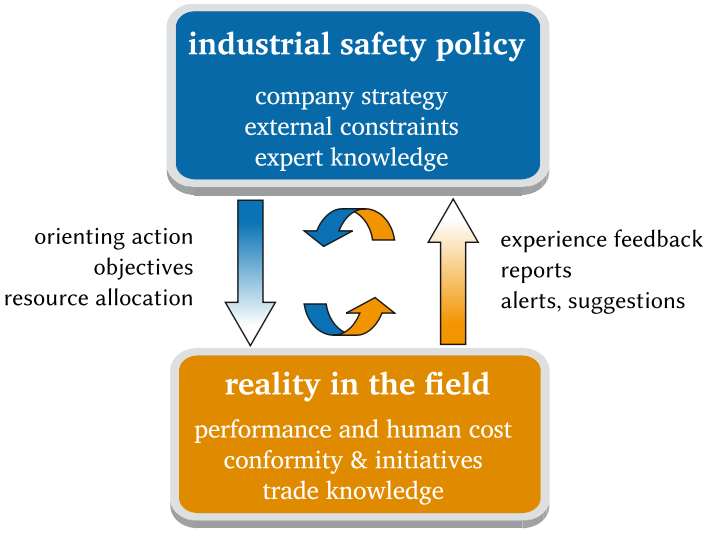


Figure 11.1 – *Coordination of top-down and bottom-up information*

- a top-down approach to guiding actions, defining objectives and allocating resources;
- a bottom-up approach to reporting information coming from workers on the front line, which serves to "irrigate" the industrial safety policy: experience feedback on incidents and accidents, raising the alarm in high-risk situations, pointing out rules that are difficult to apply, organizational contradictions, *etc.*

This upward reporting of information occurs:

- in day-to-day operations;
- when incidents or accidents take place;
- through periodic assessments.

The HOFS approach is taken into account in all areas

Human and Organizational Factors of Industrial Safety are not only the preserve of the Safety Department. Like safety in general, they need to be integrated into each of the company's policies.

Figure 11.2 – *The areas affected by HOFS*[3]

This means that all members of the Management Committee are trained in the challenges of taking Human Factors into account, or indeed that receptiveness in this area is one of the factors for choosing the men and women who make up the committee.

The following sections provide details on the conditions for integrating HOFS in various areas.

The integration of HOFS in relations with the regulatory authorities

Different industries (process, nuclear, transport, *etc.*) are accountable to different industrial safety regulators. The various regulatory authorities are currently at different levels of maturity concerning HOFS – some of them employ experts on the subject. Even when the regulatory authorities do not demand it, it is beneficial for companies to highlight the measures they are putting in place in the area of Human and Organizational Factors.

Coherence of the message

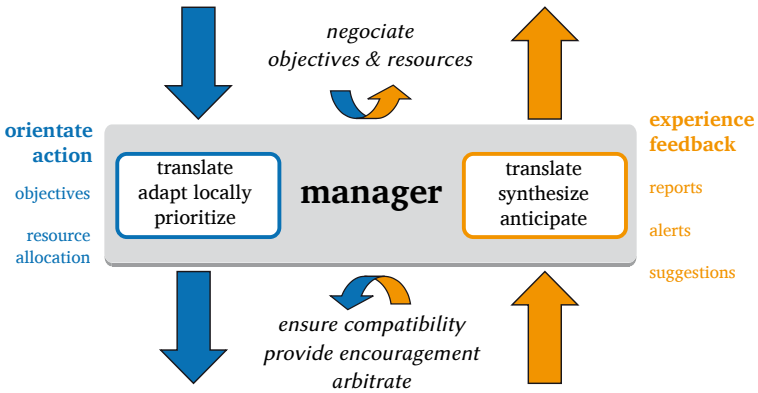
The development of a safety culture depends not only on an organization and interactions between all parties involved that facilitate learning, but also on the repeated experience of coherent behaviour: the different signals (messages, types of listening and feedback, decisions, allocation of resources) received from senior executives and all levels of management must be consistent. This is what gives meaning to the industrial safety policy.

Yet the signals are never spontaneously coherent; the company must render compatible issues that are partially contradictory: productivity, quality, safety, *etc.* An effective safety culture is one where contradictions can be pointed out and discussed, and where decisions are explicit and periodically reassessed. This coherence must be evident not only in the major objectives, but also in the details of daily life. Executives and management obey the same rules as they set for others.

Any discord between official messages and daily decisions challenges the very meaning of the safety policy. It allows people to think that they can take safety directives and adapt them into local and undiscussed arrangements.

11.3 Management's safety leadership

Each manager (executives, department heads, line managers) plays an essential role in the coordination of the top-down and bottom-up approaches to industrial safety, as indicated in Chapter 9.



Each manager contributes at his own level to this coordination between regulated security (top-down definition of the rules) and managed safety (integration of local characteristics).

Amongst other elements, management "leadership of safety" includes the following aspects[4]:

- ▷ expressing a vision of safety that is compatible with both the policy of the company and the particularities of the department;

[3] The elements of a "management style" that are conducive to the integration of HOFS are outlined in the section below.

[4] See the document published by ICSI's "Leadership in Safety" task force (in French), Leadership en sécurité: pratiques industrielles, *Cahier de la Sécurité Industrielle* number 2010-01, Institut pour une Culture de Sécurité Industrielle, Toulouse, France (ISSN 2100-3874).

- ▷ negotiating with one's own superiors the resources necessary for carrying out safety operations;
- ▷ sharing this vision of safety, by coordinating top-down guidelines and upward reporting in an atmosphere of communication and trust:
  - communicating and translating the safety rules, checking that they are being applied, organizing and leading discussions on the formulation of the rules and their implementation, prioritizing objectives, ruling on contradictions,
  - implementing safety training that is relevant for everyone,
  - gathering and forwarding experience feedback (including analyses of incidents and accidents),
  - organizing the identification of high-risk situations, including weak signals.
- ▷ integrating safety into all aspects of managing the department or the team;
- ▷ encouraging the involvement of everyone by facilitating collective approaches to safety that:
  - integrate the expertise and cultures of the different occupations,
  - encourage local coordination between safety managers and operators,
  - give their rightful place to employee representative bodies.
- ▷ being exemplary in matters of safety:
  - the manager himself follows the rules he is responsible for enforcing, including in difficult situations,
  - all parties are reminded of the safety aspect when decisions are being made about how to match resources to objectives,
  - there is the possibility of challenging decisions if the situation calls for it.
- ▷ being present in the field, paying attention to the problems encountered by operators while carrying out operations and to the human cost of performance:
  - presence in the field does not only involve safety visits by management,
  - but also paying attention on a daily basis to the difficulties encountered by operators in their work.
- ▷ managing human, material and financial resources locally, paying attention to signs relating to the health of individuals and groups, anticipating changes in the team structure (including planning ahead concerning your company's age pyramid and related training issues), organizing skills development;
- ▷ recognizing good practices, initiative, actions that contributed to avoiding an accident;
- ▷ maintaining a transparent and fair approach to undesirable behaviour:
  - not immediately blaming "human error" without thoroughly understanding the situation (see chapter 7)
  - conducting an analysis before any disciplinary action (*cf.* §7.5).
- ▷ having a duty to report to superiors when safety seems jeopardized.

Each manager has a right to expect the same level of communication from their own management as is expected from them with their own team. The idea that a "good manager" is a manager who does not have (or does not report) any problems goes against a positive safety culture.

11.4 Employee participation

Employees should be involved in:

- ▷ providing experience feedback on safety on a daily basis and when incidents occur;
- ▷ formalizing instructions for the operations that affect them;
- ▷ evaluating solutions put forward by engineers during plans for new constructions or significant modifications (see §11.7);

- evaluating the effects of organizational changes on safety.

Individual and collective safety initiatives are encouraged within a clearly defined framework.

The difficulties mentioned by employees and the suggestions they make are assessed, then a positive or negative answer is given and a record is kept.

11.5 Labour policy and employee representative bodies

The employee representative bodies are partners of senior management when it comes to industrial safety. This goes without saying for the occupational health & safety committee (known as the CHSCT in France) given its responsibilities, but it is also true for the works council, which can establish a link between financial objectives, projects, the organization, staffing changes and safety, and for the employee representatives, since they can raise the alarm, particularly with regards to individual or group health hazards that weaken the organization.

Approaches aimed at encouraging involvement from all personnel are only credible if they are accepted and supported by the employee representative bodies.

Mirroring

Mirroring can often be seen between senior management representatives and employee representatives where safety is concerned:

- *common resolve to make safety progress in a constructive manner;*
- *or a series of protests, demands and blunt refusals.*

In the second scenario, there is no point in trying to find out who is right or wrong. A change of action is called for to smooth out relations, not the opposite.

Employee representatives and senior management representatives have in common the fact that despite the legitimacy of their roles and responsibilities, they do not automatically possess in-depth knowledge of the reality of the situations in question. The humility to assess the issue by going on site to see and hear what really happens there is a useful work tool for all parties.

Obviously, the company's senior management cannot determine the positions taken by the employee representatives and the trade unions. It can, however, facilitate constructive negotiations on safety by encouraging employee representatives to attend training on HOFS, by making it possible for occupational health & safety committee representatives to be present on site, by giving precise answers to any questions raised, by including the employee representative bodies when dealing with the regulatory authority, and by providing early and comprehensive information on the planned technical and organizational changes.

11.6 Human Resources Management

The human resources department manages the pool of human resources and its development. It anticipates matters relating to **age management** by branch, establishment, department and occupation, as well as matters relating to the transfer of knowledge and to **skills building**. It plays a part in ensuring these issues are taken into account at all levels of management.

In collaboration with the occupational health department and the staff welfare department, it gathers and processes non-confidential data on the **health of employees** (absenteeism in particular) and groups (tensions, conflicts). It pinpoints "weak signals" that are likely to reveal a deterioration of safety, raises the alarm and elaborates a response with the management in question. It is careful to ensure that experienced operators whose knowledge is useful to maintaining safety are not excluded because of medical restrictions.

It **supports managers** in the local management of human resources (see §11.3 above) and more generally in carrying out their duties.

It is present in investment and reorganization projects, particularly to ensure matters relating to human resources are taken into consideration.

It contributes to promoting safety approaches that involve the personnel.

It encourages the inclusion of HOFS in the **training policy** for employees and management.

It contributes to a clear and transparent policy with regards to "error" analysis and disciplinary action.

It plays a part in occupations gaining due recognition for their role in industrial safety.

It encourages social dialogue about safety matters. It promotes actions for the development of a safety culture and participation from personnel.

11.7 The design of new facilities and modifications

The Human and Organizational Factors of Safety dimension is taken into account during any project to design new facilities or to carry out significant modifications.

A project management team is set up with representatives from production, maintenance, human resources, quality, environment, safety, *etc.* and a team leader is appointed (the unit manager, for instance). The team defines the operating objectives and ensures compatibility between the objectives and solutions in the technical, organizational, training, and roll-out areas.

In charge of defining the solutions, the engineering team interacts regularly with the project management team throughout the project, and also integrates the socio-organizational and human impacts of the solutions under consideration right from the preliminary study and through to completion.

The employee representative bodies are informed of the project prior to the design phase.

The project gives rise to an analysis of activities in at least two types of reference situations:

- an existing situation that must be expanded, moved, modernized;
- a situation presenting certain characteristics of the new planned processes (pilot site, other site).

The critical tasks and types of variabilities are analyzed in these situations through observation, interviews and document analysis.

The hazard identification and risk analysis include the **variabilities in operating conditions** thus detected. Of course, interactions with all stakeholders (elected officials, government, local residents' associations) are integrated into the management of the project.

These analyses of the existing situation are then used to define **simulation scenarios** of how the new facilities will be used. These simulations cover not only normal production situations, but also activities relating to supply chain, maintenance, cleaning, incident management, etc.

They make it possible to assess:

- the suitability of the new work facilities in terms of dimensions, accessibility, efforts, postures, information presentation, monitoring of tasks performed, *etc.*;
- the difficulties in carrying out certain tasks, the risks of accidents, the need for specific tools, procedures and training programmes.

The necessary modifications are made during the study phase, without waiting for the launch phase.

The employees located in the facilities in question (or at least some of them) are involved in the analysis of existing situations and in the simulations of the new processes. The training necessary for operating the new facilities is dispensed early enough to assist with this participation.

The launch gives rise to an HOFS assessment (especially of the difficulties encountered) and to corrective measures if need be. A new assessment is carried out three to six months after launch.

11.8 Purchasing

For products, materials and equipment with associated safety issues, the specifications include a section called "Human Factors" or "ergonomics", drafted by the principal, possibly with HOFS support. These criteria are taken into account by the purchasing department when identifying the preferred supplier.

For example, the compatibility of the equipment with the diversity of user characteristics will be checked (sizes, glasses, *etc.*), as will the clarity of the information presented, the availability of instructions in the language of the users, the ease with which consumables can be exchanged, the maintainability, *etc.*

Affected personnel and employee representatives are informed before implementation or roll-out and, if necessary, training of future users is included in the service provided by the supplier.

11.9 The definition of rules and procedures

A general assessment of the level of rules required is carried out within the company. At each site there is a description of the process for producing rules and procedures and the process for cancelling one of these. The management personnel of each unit adapt the process for rule production defined at the site, to suit local particularities.

> The words "rules", "procedures" and "instructions" have no standard definition in the field of safety. Here we use the term "rule" for a short text that defines some general principles, "procedure" for a permanent text that provides the framework for carrying out an operation, and "instruction" for a document that is specific to a particular operating context.

The definition of operating rules and procedures involves experts in the areas concerned and operators responsible for carrying out the operations in question. **Critical tasks** are identified. An analysis of existing practices and their explanations is performed.

The rules identify compulsory steps that must be executed and suggested operating procedures for achieving them. They take into account the most common variabilities.

The instructions are set out in a realistic and concrete manner. They are available near the locations where operations are carried out, as are the necessary material resources. They undergo a phase of experimentation and improvement.

The rules and procedures are periodically re-examined to take into account evaluations of the process and other rules, as well as internal experience feedback and audits.

11.10 The industrial subcontracting policy

Subcontractors play an essential role in industrial safety, both in the carrying out of their activities and in their contribution to experience feedback. Because they are not employees of the company, they are well placed to impartially report any safety issues encountered on site.

The ICSI's Subcontracting workgroup has written a decision support document[5] (in French) which you may find useful.

11.11 The organization of Operating Experience Feedback (OEF)

Feedback on the reality of activities on site[6] takes different forms.

Incident and accident analysis

Incident and accident analysis is conducted with people who are trained in the concepts and methods of HOFS. This analysis aims to uncover the deeper technical and organizational causes instead of simply blaming the event on an error made by the operator present on that day.

[5] Groupe d'Échange Sous-traitance, *La sous-traitance, guide d'aide à la décision, Cahiers de la sécurité industrielle* number 2008-04, Toulouse: ICSI, http://www.icsi-eu.org/francais/dev_cs/cahiers/

[6] Depending in the industry, this activity is called *operational experience feedback* (nuclear), *incident reporting*, *learning from accidents*, or *organizational learning*.

Analysis of day-to-day operating issues

Analysis of day-to-day operating issues requires the manager to be present on site (to conduct safety visits in his role as manager, but not only for that reason) and requires him to be attentive to the teams and different occupations. It is dependent also on the organization of briefing sessions before critical tasks are performed, on debriefing meetings being conducted for activities that presented particular challenges and, more generally, on the participation of personnel.

Reporting of information by employee representative bodies

See §11.5 above.

Periodic reviews or audits

Periodic reviews are carried out by the production teams and management to assess the conditions for performing critical tasks.

External audits comprise not only an evaluation of compliance to the rules, but also an examination of how safety initiatives are encouraged and managed. The different processes described here are analyzed.

The strengths and weaknesses of the organization are periodically reviewed with external support, in order to detect changes that signal a migration of the system outside of its safe operating area.

Listening to whistleblowers

Safety warnings that are communicated upwards by all of the means outlined above are analyzed and dealt with at each level of management.

There is an anonymous system in place, which is independent of management and allows any employee or contractor to report a situation they believe to be a threat to safety. The corresponding red flags, their analysis and the measures taken, if any, are made public within the company.

These different elements of experience feedback are integrated into the management system at all the decision-making levels within the company.

The Institute for an Industrial Safety Culture and the Foundation for an Industrial Safety Culture have gathered a significant amount of feedback on the forms of OEF implemented within member companies. Updated information can be found on their web site[7].

11.12 Organizational reviews and managing organizational changes

As described in §9.3.4, organizational reviews are regularly conducted within establishments and departments, in order to identify the strengths and weaknesses that exist at the junction of the organizational structures, the cultures and the forms of interaction.

Organizational changes are likely to affect the balance of a system and jeopardize its safety[8]. When an organizational change is necessary, it is first defined in terms of objectives and not of solutions. A project management structure is set up, with a decision-making level (executive committee) and a choice investigation level, which includes members of the management teams of the sectors in question.

Several solutions for organizational structures are outlined, and within the "choice investigation group" their effects are modelled for the various critical moments of the lifecycle of the process (start, stop, incidents, *etc.*). The advantages and disadvantages of each of the solutions are described, to guide the decision-makers in their choice. The planned changes are presented to the employee representative bodies before the final decision.

Information and training on the new organization are rolled out well before its implementation. Availability of the necessary material resources and information for the new system of operation is planned. Local government bodies and anyone affected by the risk are warned of

[7] http://www.FonCSI.org/

[8] This is why the *International Atomic Energy Agency* produced the INSAG-18 document *Managing Change in the Nuclear Industry, the Effects on Safety.*

the change beforehand if it affects an organization that had been described in the application for an operating authorization.

The new organization is the subject of an observation phase that includes a set of "sensors" and indicators for quickly detecting issues that may arise in terms of performance, safety, or cost to the employees.

11.13 In conclusion: SMS and HOFS

The information presented in this guide aims to increase the relevance of the Safety Management System, by ensuring it is based not only on the knowledge of the experts, but also on that of the employees and work groups that perform the operations on a daily basis.

Industrial safety can be achieved by anticipating undesirable situations and defining rules to avoid and manage them, by developing a safety culture that influences daily practices, by implementing technical and organizational conditions that facilitate safe operations in real conditions, and by upward reporting of the operational realities.

The idea of "critical tasks" forms the common factor in the structure of an SMS and the HOFS approach. Emphasis is placed on the tasks to be performed (and not just on behaviour), on the variabilities that are likely to appear, on the human and material resources and the rules that facilitate the completion of the task, and on the necessity of staff involvement in the deliberation process. Companies that embark on both an HOFS process and International Safety Rating System® audits can make this element a guarantee of overall coherence[9].

The members of staff, the occupational groups, the representative bodies and the contractors all have an essential role to play in the safety policy, because of their capacity to detect high-risk situations on the front line and to suggest changes. Their contribution is recognized, as are the difficulties they encounter in using the system. Compatibility between objectives and resources is periodically reassessed directly in the field.

Management plays an essential role in the coordination of "regulated safety" and "managed safety". Its preparation for this role and the support it receives to perform it are major elements of the Safety Management System.

[9] In version 6 of ISRS, the fourth element "Critical task analysis and procedures" is only compulsory from level 9, and the sixth element "Observation of tasks" from level 10. It is highly recommended to choose these optional elements as early as levels 7 or 8 to increase compatibility between the ISRS approach and the HOFS approach.

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