AIDES
A LA REFLEXION

Serious injury and fatality prevention

Focusing on the essential

"Serious Accident Prevention" discussion group

Publication coordinated by Michel Descazeaux, Jean-Claude Rebeillé, Camille Brunel and Damien Santa-Maria

n° 2019-05

THEME

Safety culture

Les Cahiers de la sécurité industrielle

ICSI
Institut pour une culture de sécurité industrielle

Seveso, Bhopal, Enschede, Fukushima… we can all recall examples of accidents or incidents that had a major impact on the environment, devastated families, or jeopardised the economic activity of a particular area.

Given the technical complexity of the subject, the challenges associated with safety, and territorial development imperatives, all stakeholders need to play an active role in the risk management process.

Progress in industrial safety must come from all actors, which is why it is crucial for them to acquire and develop a true safety culture.

That is the mission of the **Institute for an Industrial Safety Culture** (ICSI), a French non-profit organisation founded in 2003. ICSI is the fruit of a joint initiative between industrial companies, academics, researchers and regional/local authorities working together to:

- improve safety in companies by taking into account all aspects of industrial risk: technical, organisational and human,
- promote open and participatory debate between high-risk companies and civil society, through better "education" in risk management and safety improvement,
- encourage all members of society to become familiar with the problems surrounding risks and safety.

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This document

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Authors	The ICSI "Serious Accident Prevention" discussion group
Publication date	December 2019

This *Cahier* presents the findings of the ICSI "Serious Accident Prevention" discussion group after three and a half years of investigations and deliberations on the subject. Its publication was coordinated by Michel Descazeaux, Jean-Claude Rebeillé and Damien Santa-Maria.

About the authors

The authors of this *Cahier* are members of ICSI's "Serious Accident Prevention" discussion group. This group includes representatives of industrial companies from various sectors, as well as trade unions, associations and researchers.

It was launched officially on 30 October 2014.

About the coordinators

The discussion group's work was coordinated by Michel Descazeaux, Jean-Claude Rebeillé, Camille Brunel and Damien Santa-Maria, all members of ICSI's consultancy team. They are experts in safety and in the human and organisational factors of safety.

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Preface

In the field of safety, paradoxical phenomena are sometimes observed: for years we have been witnessing a marked and constant decline in the overall number of accidents, yet over the same period the number of serious injuries and fatalities has tended to stagnate, or at least its decline has been much slower than that of more minor accidents.

Given the difficulty in finding long-term solutions to this scourge, a discussion group was formed under the aegis of ICSI. It included industrial companies, client companies and contractor companies, but also trade unions, associations and safety experts. A first *Cahier* published in 2017 presented the discussion group's preliminary findings regarding the implementation of golden rules. This *Cahier* presents and summarises the fruit of nearly four years of work, discussions and deliberations.

First and foremost, this research reminds us that a safety culture must be built on a shared awareness of the most significant risks if it is to be effective, and that focusing on the incident rate can be misleading. It also invites us to take a new approach to serious injuries and fatality prevention, focusing on fundamental concepts that need to be worked on together, such as: situations with a high potential for serious injuries or fatalities, the defence in depth system (prevention, recovery and mitigation) and the barriers that compose it (combining technical aspects, a management system and human and organisational factors), but also the disruptive elements that can constantly weaken these barriers.

The discussion group did not restrict itself to providing a new model. It also took practical steps to test these concepts at the sharp end, particularly through pilot industrial worksites for aspects relating to the client company/contractor company relationship, and workshops conducted to validate the new approach.

I would like to thank all participants for their significant contribution to ensuring that serious injuries, fatalities and major technological accidents are appropriately taken into account once again. I hope you enjoy reading the information presented here. May you make good use of it by taking decisive action to reduce the most serious accidents. This is, after all, an ongoing priority for all ICSI members.

Toulouse, 13 February 2019

Ivan Boissières,

General Manager of ICSI

Preamble

How many times have we heard complaints such as "Yet another death; we don't know what to do. We've tried everything" or "There's been a big drop in accidents within my company over the last few years, but really serious accidents are still happening".

Should companies just resign themselves to this situation and consider it unavoidable? In the absence of a one-size-fits-all solution to this situation, some experts and representatives of industrial companies, trade unions, associations and institutes formed a discussion group to consider new ways to tackle the problem.

This *Cahier* summarises the results of the group's discussions and of the work it conducted with companies from late 2014 to mid-2018. We do not claim to have all the answers, but we all wanted a fresh vision and to be as thorough as possible so that these new ideas could actually be implemented.

Reading this *Cahier* should enable you to consider the issue of serious injury and fatality (SIF) prevention from a different angle. It will then be up to you to adapt the information to the reality of your organisation and, more importantly, to that of your teams, which are made up of individuals with ideas, mental models and a culture, elements that must be taken into account if progress is to be made.

The meetings held by the discussion group revealed that, where SIF prevention is concerned, companies should invest in four areas:

- implementing a small set of simple, unbreakable rules that apply to everyone, often called Golden Rules;
- improving client company/contractor company cooperation;
- paying attention to SIF precursors and addressing them;
- ensuring that the management levels, indicators and conditions required for a successful implementation of this new prevention system are in place.

This *Cahier* titled *Serious Injury and Fatality Prevention* aims to provide a summary of the results of the discussion group's work.

A separate *Cahier* is dedicated to the topic of *Implementing Golden Rules*. We will be referring to it in this publication[1].

Client company/contractor company cooperation is central to the approach, as it is essential to improving SIF prevention results. A large portion of this *Cahier* is devoted to this topic, because this relationship often needs to be rebuilt on new foundations to ensure mutual success.

Toulouse, september 2018

Michel Descazeaux, Jean Claude Rebeillé et Damien Santa-Maria

1. Descazeaux, M., Rebeillé, J.C., Brunel, C., Santa-Maria, D. (2017). *Implementing Golden Rules*. Issue 2019-04 of the *Industrial safety reports* collection, Institute for an industrial safety culture (ICSI), Toulouse, France. Available s free download from www.icsi-eu.org

Acknowledgements

This *Cahier de la sécurité industrielle* is the result of the work conducted by the "Serious Accident Prevention" discussion group, which met between late 2014 and mid-2018.

ICSI would like to thank the people who contributed to the creation of this document by participating in the debates that took place within the working group and sharing their experiences. We wish to extend a special thank you to the associations, institutes and experts[1] that helped the discussion group reach important milestones, and more particularly to the trade unions, which were highly represented and active throughout the work process. It is also worth noting the constant involvement of the client companies and contractor companies that helped to elaborate upon the issues and challenges of their cooperation, and of those that

Members of the discussion group[2]

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BERROCAL Francis	BASF France
BETTON Florence	Alstom
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DESMARETS Bernard	EDF
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DUPONT Jérôme	Total
FAUCON Didier	EDF
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KEROULLE Serge	Mase
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1. Florence Betton (Alstom), Sophie Clerc (Bouygues Construction), Chabanne Mazri (Ineris), Jean Paries (Dedale SAS), Denis Besnard (ICSI), François Daniellou (ICSI - FonCSI),
2. And of the working group which preceded the discussion group

MASSET Pascal	BASF France
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MOUSSADEK Abderazzak	Suez
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SOREAU Philippe	Arkema
VEDEL Franck	Alstom
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Internal contributions

This *Cahier de la sécurité industrielle* has benefited from the comments and suggestions made by:

- ICSI's internal teams, including the consultancy and expertise division;
- Ivan Boissières, General Manager of ICSI;
- François Daniellou, Scientific Director at ICSI-FonCSI.

ICSI's boards and committees

SAC: Steering and Assessment Committee

BoD: Board of Directors

The ICSI coordinators

Michel Descazeaux, Jean-Claude Rebeillé, Camille Brunel and Damien Santa-Maria coordinated the various stages of the group's discussions and the drafting of this *Cahier*.

Contents

Executive Summary

The creation of the "Serious Accident Prevention" discussion group was prompted by unresolved questions: "Why are we failing to reduce the number of serious injuries and fatalities more rapidly than all accidents combined? What can we do to remedy this?"

The discussion group was active for three and a half years and convened sixteen times. It also had several studies carried out, about accident statistics and Golden Rules, then two worksites were used as pilots to study cooperation between client companies and contractor companies. A number of workshops were also held, to familiarise the operational teams with the concepts developed in the SIFP Model.

The discussion group participants rapidly formed the view that different methods to the ones usually applied needed to be implemented to address workplace accidents.

Their work highlighted the fact that serious injuries and fatalities need to be tackled according to the type of accident scenario. The standard general measures ordinarily applied for prevention are based on the idea that by reducing all hazardous situations and near misses, without any consideration for their potential severity, eventually the number of serious injuries and fatalities would drop just like the others. This idea was proven to be flawed, by a lesser reduction in the number of serious injuries and fatalities compared with the trend observed across all accidents.

On the strength of this, a suggestion was made to start with scenarios characterised by a previously determined situation with a high SIF potential (SHSP). For each SHSP scenario, characterised by a clearly identified SIF potential, a defence system is needed. This system includes three levels of defence: prevention, recovery and mitigation. These three levels are each composed of one or several barriers, i.e. a set of measures relating to the technical aspects, the safety management systems (SMS) or the human and organisational factors (HOF).

To avoid accidents and their consequences, it is important for this defence system and its barriers to be appropriate for the long term and to remain robust over time; even more importantly, they must be in place when needed (kinetics). Any failures of this defence system must be observed, minimised and neutralised.

Real situations with a high SIF potential (SHSP), also called "precursors", are the first sign of a loss of control in the defence system. They are situations which the defence system can recover. It is therefore crucial to detect, compile and analyse them to find corrective measures. A high-potential incident (HIPO) is the accidental event that will occur if control is not recovered following an SHSP.

Disruptive elements are phenomena that weaken the levels of defence, either directly or when combinations of them are present. Consequently, it is important to know them, detect them and address them. These disruptive elements reveal organisational weaknesses, either internally or related to third parties. They can also be due to external factors or individual failures. By analysing these disruptive elements and their possible combinations, it is possible to be alerted in time and to find fixes.

This defence system forms the core of the system called "SIFP Model".

Among other elements, this model includes two levels of management: local (nearest the sharp end and "tailored") and overall (general monitoring and "ready-made"). Certain general measures called "common prerequisites", such as Golden Rules, a just culture, and a policy of cooperation with contractor companies, are important factors for success.

This set of measures is illustrated in a concise diagram of the SIFP Model, depicting the new approach to tackling the SIF issue.

Two other themes are explained in this *Cahier*: client company/contractor company cooperation, and the transformation required to shift from usual prevention to prevention which specifically takes into account serious injuries and fatalities.

Preventing contractor-company accidents is important, because their number is often high. Indeed, contracting is increasingly common in many activities and some of these are more exposed. The client company/contractor company relationship is therefore a major contributor to SIF prevention. By analysing the different aspects of this relationship through the lens of the SIFP Model and examining the common safety culture construct between client company and contractor companies as well as the chronology of the stages of the business relationship, it is possible to better identify the points needing improvement and facilitate mutual progress. Client company/contractor company cooperation should therefore be taken into consideration systematically.

Finally, the shift from standard prevention to SIF prevention requires a certain number of steps. This transformation is similar to the change management required to shift the safety culture to an integrated safety culture. In fact, a change of safety culture is often what is needed. To be successful, the construction of the SIFP Model and the safety culture transformation should be carried out in tandem.

The discussion group had first examined the question of Golden Rules. Indeed, at that time, many companies had begun to introduce this approach or were planning to do so. Based on the group's work, the *Cahier* titled *Déployer une démarche Règles d'or* was published in 2017. Its English version, *Implementing Golden Rules*, was released in 2019. The conclusion of said *Cahier* made it clear that implementing "Golden Rules" or "Life-saving Rules" was not sufficient for tackling SIF prevention. However, this type of initiative does go a long way to changing mindsets or even the company's culture, by placing focus on SIF prevention. The eight principles developed in the *Cahier* made it possible to accurately identify the steps involved in such an undertaking, as well as the factors for success.

In summary, the *Cahier* presents the results of the work carried out by the discussion group. The participants found it greatly rewarding to share their experiences, get involved and offer solutions to as yet unresolved problems. These discussions made it possible to consider innovative avenues which do not presume to solve everything but open up possibilities for a new approach to SIF prevention (SIFP).

Introduction

This document

This *Cahier* summarises the work carried out by the "Serious Accident Prevention" discussion group. It summarises the discussions that took place during the group's meetings, as well as the good practices shared by the group's members. It also includes the results that emerged from the pilot worksites that were set up and from the studies and workshops conducted at the sharp end. It was preceded by the publication of a separate *Cahier de la sécurité industrielle* about *Implementing Golden Rules*. It will be further supported by various other materials (lesson, video, slideshow with commentary, etc.) on the topics covered, as part of the "Focusing on the essential: preventing serious injuries, fatalities and major technological accidents" process initiated by ICSI.

It is important to remember that when it comes to safety nothing is set is stone; operational experience feedback can gradually enrich current thinking to improve SIF prevention. This *Cahier* aims to present an overview of a new approach that will be improved upon by those who implement it and are willing to share the lessons they learn along the way.

Its target readership

It can be useful to individuals in the following positions:

- Executives, directors and managers;
- Executive Committee members of establishments or industrial sites;
- HSE departments and support functions;
- Secretary or member of the health and safety committee or the equivalent of the latter in countries outside France.

Serious injury and fatality prevention: is a specific approach required?

SIF prevention requires a specific approach different to the one generally used to reduce the number of occupational accidents. Indeed, the causes of serious accidents fall into different categories, for example their cause may be linked to the work environment (work at height, in trenches, etc.), the industrial processes or procedures being applied by the workers themselves or someone nearby, or the risks associated with simultaneous operations (SIMOPS). Furthermore, it has been noted that a decline in the incident rate (number of accidents relative to the number of hours worked) does not mean a concomitant decline in the number of serious injuries and fatalities. The discussion group had a study performed on this subject. Along with other studies, it confirms that where accidents related to the work environment are concerned the number of fatal injuries is on a slower decline than the number of non-fatal injuries[1].

1. Krause Bell Group: 1993 – 2012: Non-fatal injury rate: illnesses/100 employees 8.5 → 3.5; Fatal injury rate (fatalities/100, 000 employees) 5.5 → 3.5 (US private industry) - 2016 Krause Bell Group - OGP statistics 2016: since 2011, the fatal accident rate (per 100 million hours worked): 1.9 → 1.8 The TRIR (number of recordable accidents per million hours worked): 1.8 → 1.

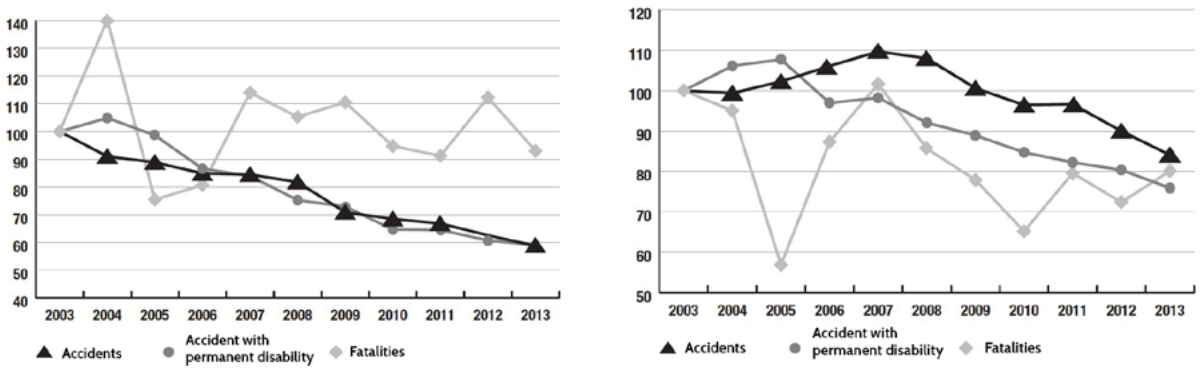

FIG. 01: *Accident trends 2003 - 2016: metallurgical industry in France and construction industry in France*[2]

On average, the rate of fatalities between 2003 and 2013 was relatively stable, whereas there was a steady decline in accidents overall.

This could be described by the expression "The pitfalls of the Bird pyramid". The proportionality between minor incidents and serious accidents would only hold true if the mechanisms leading to the accidents were the same. Yet, all the evidence seems to indicate that is not the case. We therefore give too much importance to minor accidents (injury free), by devoting a lot of time and energy to them.

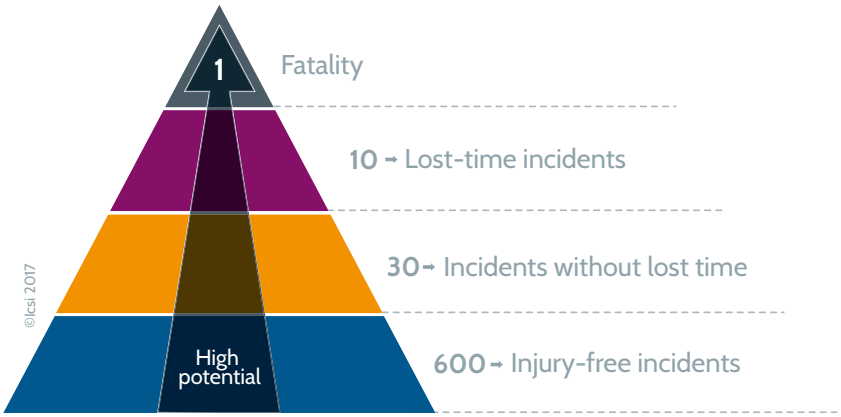

FIG. 02: *The Bird pyramid*

Based on statistical data, the Bird pyramid shows the numbers of incidents in four categories: fatalities, lost-time incidents, incidents without lost time, and injury-free incidents.

Only a portion of the base of the pyramid (HIPO incidents) concerns the mechanisms likely to cause a serious accident.

2. Study carried out by ICSI students on behalf of the discussion group (2015) – source: Assurance Maladie - France

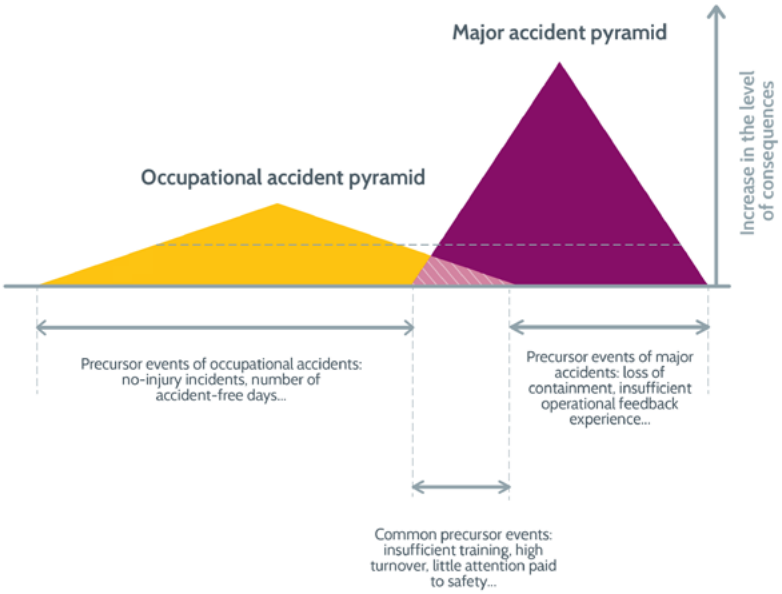

FIG. 03: *Combination of the pyramid model and occupational accident statistics*[3]

This diagram illustrates the fact that a portion of major accidents, referred to as "technological or industrial", and a portion of occupational accidents are preceded by common events or precursors.

All incidents likely to lead to serious, fatal and major accidents must be considered. They can have serious or even fatal consequences. "Occupational" accidents and major accidents, referred to as "technological", share some of the same causes, as shown in Figure 03. Where SIF prevention is concerned, it is not appropriate to distinguish between industrial safety and occupational safety.

The fundamental issue: reducing the number of serious injuries and fatalities is a priority.

In general, when faced with problems, we start by dealing with the ones that have the most significant potential consequences. When it comes to accidents, this is proving very hard to do. This is an indication that the classic methods, based on general measures which are not specific to serious accident scenarios, have reached their limits. That does not mean we should do away with them, since they have made it possible to improve occupational safety considerably, but they do not guarantee sustained progress in preventing serious injuries and fatalities. Yet companies increasingly consider the human, economic and image-related consequences of these incidents to be major.

It is important to know how to identify and address the situations carrying the most risks, i.e. "situations with a high SIF potential" (SHSP)

Due to the non-linearity of the "accidents-incidents-causes" chain, we cannot hope to eliminate serious accidents by focusing only on reducing the number of incidents or minor accidents without regard for SIF potential. This means that, in order to prevent these serious accidents effectively, we must analyse and reconstruct the scenarios in which they occurred. By working on the most hazardous situations and on HIPO incidents, it is possible to break away from the widespread approach focused on reducing the base of the Bird pyramid.

Identifying situations with a high SIF potential is therefore a necessity. They make up a portion of the base of the Bird pyramid, called "prevention diamonds", but generally speaking they are neither identified by traditional methods nor addressed.

3. Mazri, C. (2016). From a presentation made to the "Serious Accident Prevention" discussion group. Ineris.

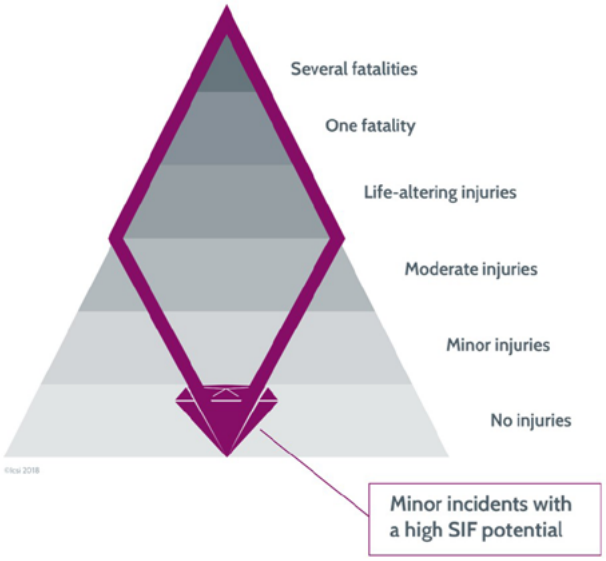

FIG. 04: *The diamond in the Bird pyramid: situations with a high SIF potential*

A portion of the Bird pyramid base is made up of incidents and, more broadly, of situations with a high SIF potential (SHSP), which may or may not evolve to become major, serious or fatal accidents. These situations called "serious injury or fatality precursors" (SIF precursors) are very important and precious to detect and to extract from the mass of information that can be reported. Indeed, these "diamonds" can teach us a great deal about the latent factors and various causes that can contribute to these accidents.

SHSP or SIF precursor

Definition

A situation with a high SIF potential "*is an uncontrolled high-risk situation which will result in serious or fatal injury if left unchecked.*"

Webinar - BST solutions.com (Krause, 2012)

SHSP illustrate what it is important to look for amongst what we generically call "*hazardous situations*". From among these we must distinguish the ones that have a high SIF potential, i.e. those that are "potentially SIF" (*Fig. 05*). To get the most out of SHSP or SIF precursors, a set of organisational measures (system for reporting and processing the information – search for root causes) and actions aimed at the human levers (motivation, recognition, error handling, etc.) are required.

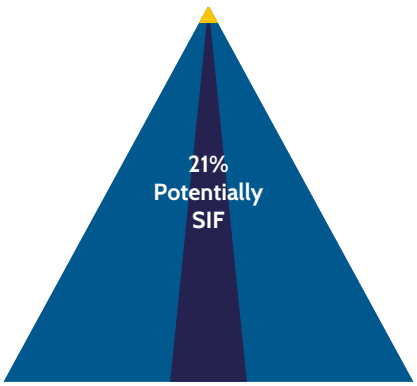

FIG. 05: *Potential serious injuries and fatalities (SIF) - SIF Prevention study, T. Krause (2016))*

The precursor: the critical point preceding the loss of control

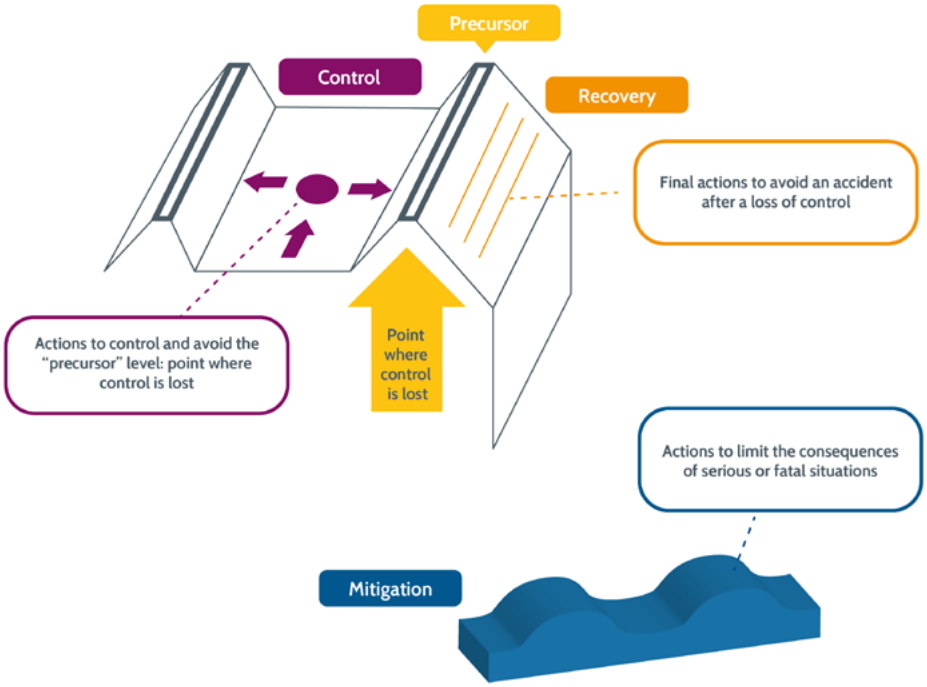

FIG. 06: *The SIF precursor (SHSP): the point where control is lost*[4]

Under normal circumstances, risks are constantly controlled, either by clearly defined measures which are known and applied; by the use of technical prevention systems or corrective actions; by the sharp-end worker; or thanks to the vigilance of other parties who can step in to correct actions underway. Most often, controlling risks takes up most of the time spent on activities. Different factors can lead to a situation with a high SIF potential. Broadly speaking, this is a loss of control. If the situation is not recovered it will inevitably lead to an accidental event. Mitigation actions can limit the severity of the event's consequences.

Before the point where control is lost, the situation is stable and the regulation of safety is "*homeostatic through closed loops*", "*incident-based management*" is "*proactive*", "*reversibility is very high*". Loss of control can lead to a serious injury or fatality. Recovery measures can re-establish control over the situation. Mitigation measures can limit the consequences of any accidental event that might occur.

About the creation of this *Cahier*

A five-step process was followed:

1. The discussions of the "Serious Accident Prevention" discussion group during their meetings held between 30th October 2014 and 06th June 2018 were compiled and summarised. This summary was supplemented by the results of studies, pilot worksites and workshops conducted by various participants and members of ICSI, as well as a commentated slideshow which was submitted to the discussion group members for their opinion and tested at the sharp end by some of the participants;
2. A working document was created and kept updated as the discussion group's work progressed. It contains the results of this work and was regularly submitted to the participants for review and comment. It is a compilation of the elements that were produced and, along with the slideshow about the SIFP Model, it served as a basis for the drafting of this *Cahier*;

4. Pariès, J. (2016). From a presentation made to the "Serious Accident Prevention" discussion group. Dédale SAS.

3. ICSI then drafted a finalised document that could be submitted to the members of the discussion group for review once it had undergone scientific validation internally at ICSI;
4. ICSI then consolidated and formatted the document before submitting it to the participants for final approval;
5. The "*Serious Injury and Fatality Prevention*" *Cahier* was finalised.

Document outline

Part One of this *Cahier* presents an overview of a new approach to serious injury and fatality prevention.

Drawing on the strategies outlined in Part One, **Part Two** helps to understand and explain the different elements of the general model for preventing serious injuries and fatalities that will henceforth be called "SIFP Model". This model comprises five important elements that explain the way to drive SIF prevention: situations with a high SIF potential (SHSP), the SIF precursor concept, the "Prevention – Recovery – Mitigation" (P.R.M.) defence system, disruptive elements and their fixes, and the conditions for a successful SIFP system, particularly the different levels of management (*see Part Two*).

These five elements are the culmination of the group's discussions regarding the model. They summarise the main ideas that emerged.

In order to give firm definition to the overall system, two other major themes are discussed in Part One:

- Client company/contractor company cooperation, due to the high number of accidents among contractor company workers[5];
- The transformation towards a new approach to SIF prevention.

Both of these themes were the subject of discussions, and the first was the focus of some pilot worksites. The remainder of the *Cahier* is devoted to a more detailed presentation of each of the themes discussed in Part One, with the aim of providing methodological elements:

- Part Two: The SIFP Model and its components;
- Part Three: Client company/contractor company cooperation;
- Part Four: The transformation towards a new approach to SIF prevention.

What this document is and is not

This *Cahier* is not in any way intended as a guide providing ready-made, "one-size-fits-all" solutions, nor as a conclusion to the subject covered in the discussion group. It is neither exhaustive nor set in stone. It is a document reflecting the current thinking and findings of the "Serious Accident Prevention" discussion group and thus it is bound to evolve. Although this *Cahier* presents an assessment that was, for the most part, shared by all the stakeholders represented in the group, it is important to stress that a consensus was not reached on some of the points and in fact there were some diverging opinions among the participants.

This *Cahier* is therefore more of a starting point for the work to be continued on this subject.

5. More than 50% for some of the big companies that participated in the discussion group.

Part One

General overview of a new approach to SIF prevention (SIFP)

1

The SIFP Model

1.1 Loss of control over potentially serious situations

The concept of SIF precursors (SHSP) is major. Indeed, serious injuries and fatalities are fortunately rather rare. Identifying situations with a high SIF potential before an accident occurs is becoming crucial. These are situations where although nothing happened, the consequences could potentially have been very serious had the situation not been recovered.

The loss of control, or precursor, results from the combination of preventive measures becoming weakened and a situation with a high SIF potential once the critical point has been reached (*see Fig. 06*). The severity potential represents the possible consequences of the accidental event. These consequences can affect people, the environment, the facilities and the company.

1.2 The defence system

This general idea led the discussion group to work on the idea of situations with SIF potential and that of serious accident scenarios in the event of a loss of control. The weakening of prevention measures leads to questions about their nature and their complementarity. Indeed, the precursor precedes the accidental event and the situation can be recovered through measures prepared or decided upon in real time (managed). That is actually frequently the case because, most of the time, by recovering situations with SIF potential, serious injuries and fatalities can be avoided.

Furthermore, it is known that the consequences of an accidental event can be reduced by the use of personal protective equipment or by collective measures to organise emergency response, for example.

Three defence system levels composed of measures called "barriers" were thus revealed by the discussion group for each SHSP scenario:

- **The prevention level**, to prevent the occurrence of a situation where control is lost (precursor);
- **The recovery level**, to recover a situation where control is lost and restore a normal, controlled situation;
- **The mitigation level,** to limit the impact or consequences of any accidental event that does occur.

Definition

The P.R.M. defence-in-depth system

A P.R.M defence system for SIF prevention comprises three levels of measures or barriers for each serious accident scenario characterised by a situation with a high SIF potential: **prevention, recovery, and mitigation**.

1.3 The serious injury and fatality prevention model

Taking into account the precursor and accidental event concepts, the discussion group summarised the SIFP Model in a diagram, for an SHSP scenario and its three levels of defence.

The different levels of defence are weakened by disruptive elements. It is often the combination of these disruptive elements that weakens the defence system. This can result in a precursor (SHSP) if the prevention barrier is weakened, an accidental event if the recovery barrier is weakened, or severe consequences if the mitigation measures are insufficient.

Two levels of management are depicted. One, close to the sharp end, is directly concerned with implementing the three levels of defence and monitoring their effectiveness using information from precursors or accidental events in particular. The other is more overarching, managing several entities. It focuses more on monitoring method implementation, overall results, and the more complex cases to address.

Prerequisites are general measures which are essential conditions for a successful implementation of SIF prevention. Examples: golden rules, client company/contractor company cooperation policies, etc.

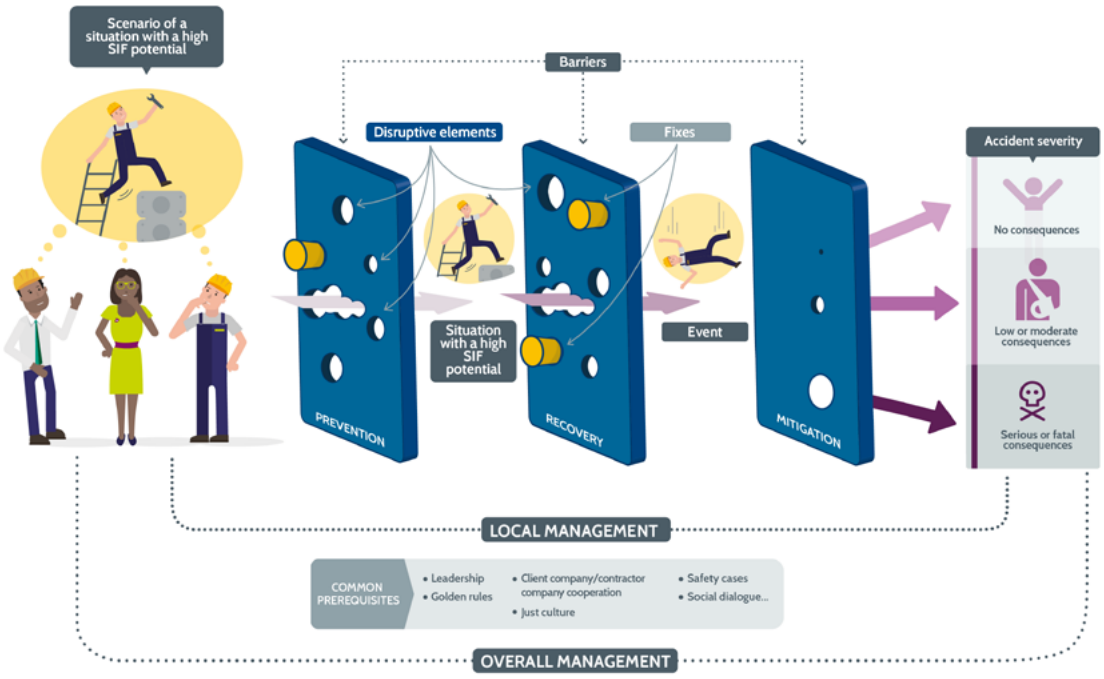

Fig. 07: *The serious injury and fatality prevention model*

The development of this model will be discussed in Part Two, Chapter 6 of this *Cahier*.

2

The client company/contractor company relationship

2.1 An observation

The number of serious accidents involving employees of contractor companies is often greater than the number involving client company employees. This observation is based on the statistics provided by companies for the last few years.

The proportion of work that is contracted out varies according to the type of activity. Therefore, this observation does not necessarily apply across the board. Often, the activities that are contracted out are those that expose workers to the most risks; this can amplify the number of injured persons relative to employees of client companies. The discussion group endeavoured to analyse the aspects of the relationship on which it seemed useful to focus in order to improve SIF prevention.

"Contractor company" should be taken to mean any company external to the client company. Indeed, suppliers sometimes work directly on their client's site, during chemical transfers for example, and client companies sometimes work at other companies' facilities. These joint activities can be sources of accidents and warrant an approach of the same type.

2.2 The important aspects of the relationship that have an impact on SIF prevention

SIF prevention requires common approaches to be adopted in order to make progress together in certain areas. Among these, the discussion group highlighted:

- A shared vision of serious accident risks;
- The nature and content of contact with the sharp end;
- The contract procedure;
- The creation of a common cultural "construct";
- Regular management reviews performed jointly;
- The transparency required in these matters;
- The decisions/trade-offs made and the basis for these.

2.3 A method for evaluating the cooperation

The discussion group's work made it possible to design a method for evaluating the client company/contractor company relationship from the perspective of SIF prevention.

This method is structured around:

- A shared vision of the SIFP Model elements;
- The state of the "common safety culture construct";
- A chronological approach to projects or operations handled jointly, with a vision of these stages focused on SIF prevention.

3

The transformation

3.1 The essence of the debates regarding the shift towards an effective approach to SIF prevention.

The discussion group considered that this point was major for achieving success. The way forward is often more important than the outcome and, in this case, it is a change in culture. Indeed, for a long time, there has been a widespread belief that by eliminating the causes of all accidents the number of serious injuries and fatalities could be reduced. The general methods used – focusing on reducing the incident rate (or the TRIR), setting objectives to this end, implementing a recognition policy for this aspect only – have become rather ingrained.

The fact that occupational safety and industrial process safety have often been strictly separated in guidelines, policies, organisational structures and management, is often highly pervasive in the ways of doing and thinking.

The new approach put forward, based on the work carried out by the discussion group, challenges this vision and thus all of the cultural aspects linked to it: at the individual level, but also where the managers, training programmes, management systems and performance management systems in place are concerned.

3.2 The stages of the transformation

This being a culture transformation, the discussion group drew on the general approach for changing safety culture elaborated by ICSI.

Fig. 08: *ICSI's general approach for evolving towards an integrated safety culture (adapted from J. Kotter)*

Five stages should be taken into account when preparing for and managing the change. These stages succeed one another and may partly overlap. They must be properly identified and adapted to the actual situation of what we want to change. They involve all individuals concerned (see Part Four).

Part Two

Detailed presentation of the SIFP Model components

1

Scenarios of situations with a high SIF potential (SHSP)

1.1 The hazard, risk and severity concepts

Identifying scenarios of situations with a high SIF potential (SHSP) involves detecting hazards, then evaluating the risks by examining all risks and the severity of their potential consequences, taking into account the prevention measures that are either in place or under consideration. Each SHSP characterises a potentially serious or fatal accident scenario based on a risk that is insufficiently covered by the defence system in place, because the latter is either weakened or poorly designed.

Definition

Hazard

A **hazard** is an intrinsic property of products, equipment, processes, situations... that can lead to harm or damage.

Examples: equipment under pressure or at high temperature, load mass (lifting, moving, etc.), an electrical network, gas or chemical pipes, the potential fall height, the kinetics of a moving vehicle or machine.

Definition

Risk

Risk results from the exposure of a target (employee, company, equipment, environment, including the general population...) to a hazard. It is characterised by the combination of the probability of a dreaded incident (accident) occurring and the severity of its consequences.

The goal is to accurately identify the situations which carry a serious risk if no measures are taken. And yet, not all situations on an industrial site have a high SIF potential. Hazard exposure is therefore important for characterising an SHSP:

- In and of themselves, an electrical network or an enclosure containing electrical equipment are not risky. But if you are in close proximity – at a distance shorter than the minimum approach distance – or working on one of these, you need to adopt special preventive measures: working only after lockout/tagout (LOTO) or applying the corresponding protocols when performing live work.
- In and of itself, a chemical or gas pipe is not a risky structure (subject to the safety case findings[6]). But special measures must be taken according to the possible exposure of individuals in the immediate vicinity or while working on the pipe. For example: lockout/tagout (LOTO), purge, shutoff... Preventive measures must be elaborated and implemented for the special circumstances in which hazardous material containment is not guaranteed (flammable, toxic or explosive mixture leak).

6. Safety case and RCM. Safety cases identify risks, based on various potential accident scenarios. RCMs: risk control measures to reduce the probability of occurrence and the impact of the risks. At industrial facilities, given these measures, not all zones are risky and thus the situations are not all considered to have a high SIF potential. However, all zones in which contractors or third parties may be exposed to the industrial risks without actually participating in operations — an example of this would be the Texas City incident, where some bungalows were present in an exposed area — must be properly taken into account.

Severity

Definition

The notion of **severity** characterises the consequences for individuals (personnel, contractor company workers, associate contractors and third parties), the facilities, the environment, and even the companies themselves and their existence.

For example:

- **Injuries or diseases** that are life-threatening:
  - Those that could have led to death;
  - Those that required the intervention of extreme emergency services;
- **Long-term life alterations due to injuries or diseases** leading to:
  - A long-term deterioration or a loss of use of an internal organ, a bodily function or a part of the body;
  - A confirmed psychological trauma.
- **The amount of damage caused** and whether or not it is reversible (environment, facilities, private property), the consequences for the company's image and existence, etc.

Severity is a notion that is variable and adaptable depending on the context. There is no one-size-fits-all definition, and it must be determined based on activities and on the consequences of accidents. Each organisation must define this notion by taking into account the risks tied with its activities.

SIF potential

Definition

SIF potential is a notion which aims to characterise the consequences of situations that could have serious consequences for people and property. It is necessary during the phase where we seek to determine which situations could potentially have serious consequences.

This can be done by establishing a list of severity criteria (frame of reference) that is updated when changes occur and when further knowledge of hazards, risks and their consequences is gained.

Severity criteria

Examples

Source of danger	Short description of the phenomena and of their potential consequences in terms of severity	Measurement/ evaluation of the potential degree of severity
Mechanical energy	**Kinetic** (mass and speed of elements in motion): moving machinery, collisions, traffic. **Potential**: falling bodies or objects, work at height, load lifting, fluid pressure, gas, mechanics. Cave-ins at excavation sites, cavities.	Speed/mass in motion Fall height: weight, perimeter, pressure...
Thermal energy	**High temperature, burns**	Temperature and pressure levels.
Chemical energy	**Explosive mixtures, acidity, toxicity...**	Level of... List of hazardous materials
Electrical energy	**Electric shock, electrocution, burns, flash**	Thresholds, voltage, current, power (short circuit))
Nuclear energy	**Radiation protection** Ionising radiation, burns	Maximum doses
Other	E.g.: confined spaces, lack of oxygen, presence of a "liquid" environment.	% toxic gas Depth of liquid

1.2 Identifying situations with a high SIF potential (SHSP): the essence of the debates

Based on the hazards and the corresponding risks, it is important to identify the situation scenarios which would have a high SIF potential if no reliable preventive measures were put in place or if these were to fail. It is essential to describe the scenario that will lead to this SHSP, as well as the ensuing developments which could bring about a serious accident.

Various methods exist for identifying and qualifying the risks and their SIF potential[7]. These methods are often divided into two categories: occupational risks and industrial process risks. Yet, as explained previously, these worlds are not separate. Individuals at their workstation are also affected by industrial risks, either because these are a part of their work activities or because an accidental industrial incident will or could have an impact on them. The work conducted by the discussion group led to taking into account this interpenetration of risks, whether these are tied to the industrial processes, the workstation, or the different SIMOPS with other workers, third parties, or works presenting hazards and situated in the vicinity of the activity.

Key point

The 360° view approach to SHSP

The 360-degree view approach to situations with a high SIF potential involves scanning all three areas: industrial processes, workstation, SIMOPS, as well as their combinations for a given activity, a series of operations, a work-site... This approach brings to light situations and their scenarios which would not have been identified without this systematic process. It must be carried out jointly, by the stakeholders most concerned. Industrial process experts and those in charge of workplace safety must especially work closely together. The following diagram illustrates the main points of the 360-degree approach to situations with a high SIF potential.

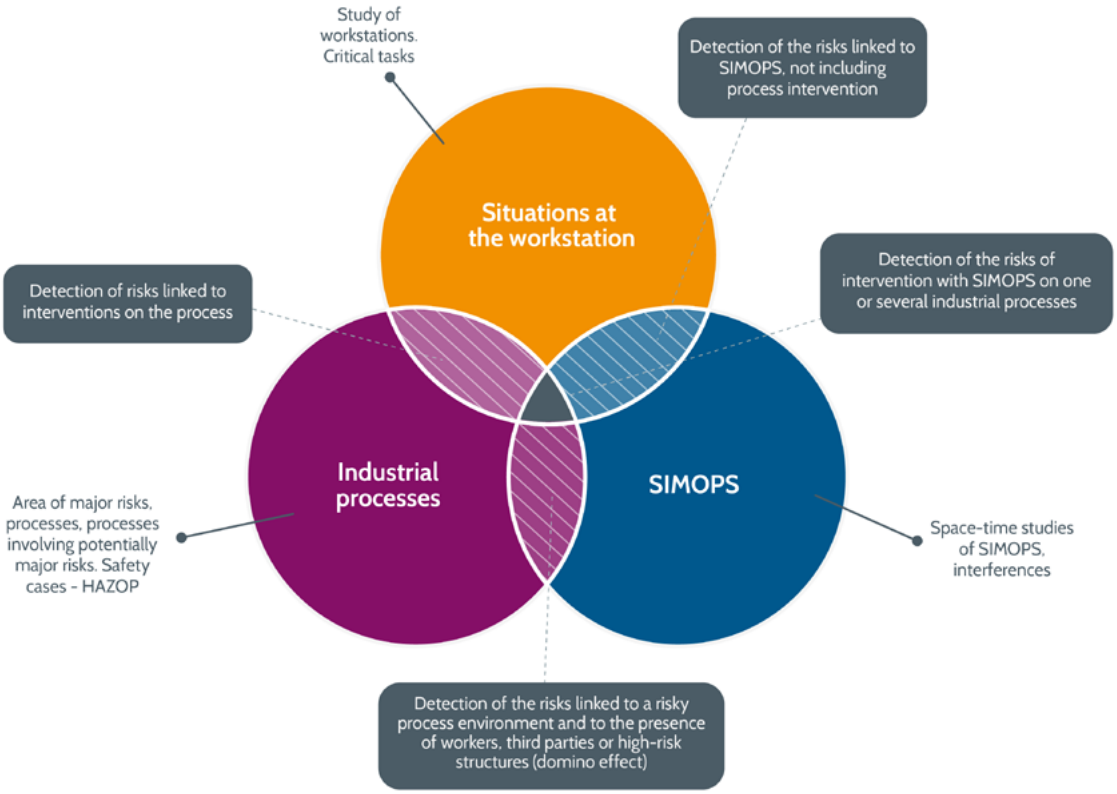

FIG. 09: *The 360-degree view approach to situations with a high SIF potential (SHSP)*

7. HAZOP, FMECA, STPA, study of workstations and critical tasks…

2

Precursors or real situations with a high SIF potential

The key element for SIF prevention is to identify, understand and control the SIF precursors.

The SIF precursor or SHSP

Definition

A SIF precursor is a real situation with a high SIF potential (SHSP), for which technical and managerial controls are absent, ineffective or inadequate, and which will result in a serious or fatal injury if allowed to continue[8].

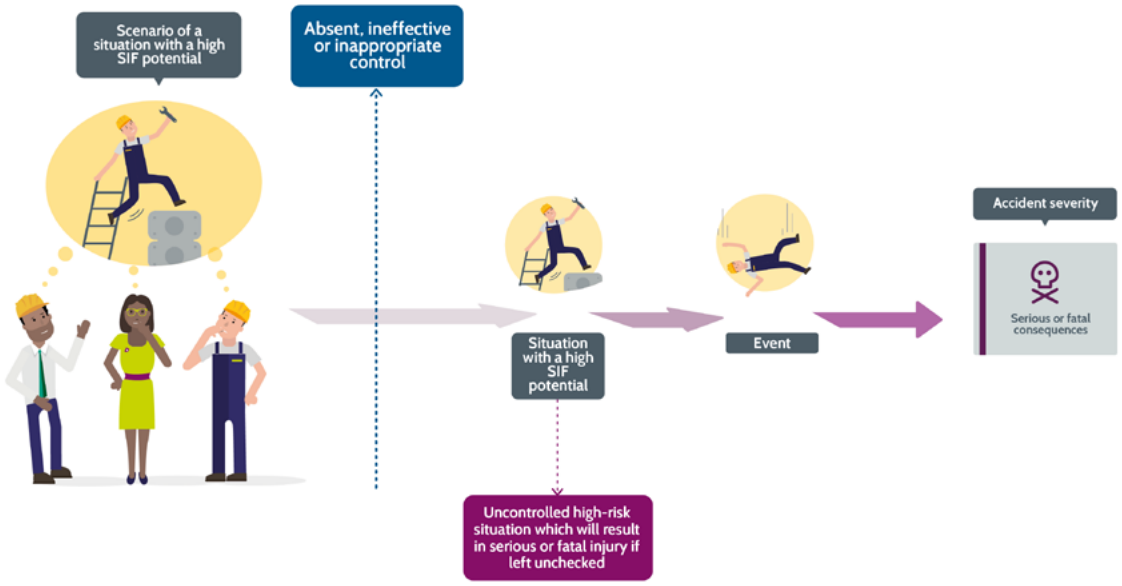

FIG. 10: *The SIF precursor or SHSP: loss or absence of control*

This diagram is based on the SIFP Model. It shows that a failure of the defence system's "prevention" level leads to the SIF "precursor" situation.

The importance of precursor detection and analysis

Key point

The SIF precursor or SHSP indicates a real situation with a high SIF potential in which an accidental event has not yet occurred. This is the case, for example, in a situation where electrical equipment is still energised after LOTO. This must be detected in order to trigger immediate recovery actions. The situation must be analysed to examine the causes behind the ineffectiveness of the defence system and of the prevention measures (barriers) in particular.

8. From Krause, Thomas R. BSTsolutions.com webinar (2012)

3

Defence system: overview of the defence-in-depth system and its barriers

3.1 The P.R.M. defence-in-depth system

It is composed of three levels of defence: prevention, recovery and mitigation. Each level of defence can include one or several barriers. Generally, the barriers relate to the three pillars of safety.

FIG.11: *The three pillars of safety*

Example

Implementation of guardrails in the construction industry

The SHSP is the risk of falling from height, one of the major risks in construction.
The prevention measures implemented by companies will pertain to the three pillars:

- technical safety: mandatory presence of a guardrail with specific technical characteristics for any situation involving work at height;
- safety management system (SMS): a "no guardrail, no work at height" rule in line with technical characteristics (safety requirements), monitoring and verification of an indicator showing the % of compliant guardrails;
- human and organisational factors (HOF): a work group that is very proactive about putting the barrier in place and following the rule, leadership, importance given to monitoring the compliance indicator, training, shared vigilance.

Note that the guardrails must be compatible with the work activity. This means that they must be positioned correctly for the way the work activities are to be carried out.

3.1.1 Prevention barrier

For an activity exposed to the risk of serious or fatal injury, one or several prevention measures may be in place, called barriers or defences.

Definition

Prevention

Its purpose is to prevent the occurrence of a risk and its impact, or to limit its probability of occurrence.

Safe work permits and associated technical and training measures (such as LOTO) are a perfect example of a widely used prevention barrier. Where safe work permits are concerned, it is important to ensure effective synergy between the three pillars governing the nature of the prevention barrier: technical aspects, management system and human and organisational factors.

3.1.2 Recovery barrier

Definition

Recovery

This type of barrier exists to recover control over a high-risk situation that constitutes a SIF precursor (SHSP).

This involves detecting the situation where control has been lost and implementing the necessary corrective actions.

Example

Proving dead

The proving dead procedure will detect whether an electrical installation has not been locked out or if the procedure was not followed correctly. Measures can then be taken to recover control over the situation and work safely. A loss of control, due to a weakening of the prevention barrier, can be detected by the safety system (*alarm, automated system*), by the person operating the equipment, or by the work group (*shared vigilance*). Control over the risk is recovered by following pre-established procedures or after stopping the work *(e.g.: STOP Card process)* and deciding on the actions to take. The recovery barrier is the one that is the least often planned in advance and prepared. Special attention must be paid to this barrier, which often relies on the worker or work group taking initiatives in real time. To make progress in this area, it is very important to listen and to capitalise on the ways of recovering situations. This approach should combine the involvement of all concerned plus a strong culture of transparency.

3.1.3 Mitigation barrier

Definition

Mitigation

The mitigation barrier aims to reduce the severity of the accidental event's consequences.

This is the case with wearing PPE when needed or a seat belt while in a vehicle or while operating machinery. Many of the consequences of serious accidents involving forklift trucks could have been mitigated: people have been ejected from the forklift and crushed by it.

3.2 The necessary complementarity of the three levels of defence

This three-layered system merely reflects what happens naturally. Indeed, there is often an established prevention measure in place to reduce risk. This is the case, for example, when a worker uses a cradle lift, where possible, instead of ladders when the situation calls for it (mitigation). If another worker remains on the ground to monitor the operation, this reinforces recovery and mitigation.

Example

The importance of accurately identifying the three levels of defence for SHSPG

Often, during safety visits, managers focus on checking that PPE is being worn, especially hard hats. When examining the three barrier levels, it is evident that wearing a hard hat is a mitigation barrier: it limits the severity of consequences in the event of falling or flying objects. What are the other barrier levels and the SHSP that warrant the wearing of a hard hat on this worksite? By reflecting on this, they will discover that falling objects can be due to a possible SIMOP on the worksite or to a rock sent flying by a vehicle passing nearby.

This will raise further questions: what measures, in terms of scheduling and team placement (no working above/below others), have been put in place to limit the risks associated with SIMOPS on the worksite? What has been put in place to limit people moving about too close to vehicles: demarcated areas and special authorisations? By pursuing this questioning, they will go further and ask themselves: what would happen if what had been put in place (scheduling and demarcation) was disrupted by an event? Has the prevention been appropriate? Are there any recovery measures in place for working above others or for moving about close to the worksite, even if there is a scheduling change?

Key point

The importance of a comprehensive view of the defence system and of its coherence

Wearing a hard hat is important, because it limits the severity of consequences if one of the other barrier levels should fail, but it needs to be positioned within the system as a whole and the three barrier levels should be discussed, particularly during the prevention visit.

3.3 The importance of the recovery barrier

As we saw previously, recovery is often frequent and natural. However, generally speaking, insufficient thought is given to the design of one or several of the recovery barriers for each SHSP. This is a stage where everyone's vigilance needs to be developed through briefings, visits and supervision. Recovery can come from general measures such as the "STOP card" or the "pause & check" to make sure we're not in a precursor situation, i.e. a situation where the prevention measure has failed. The emergence of the right questions should be encouraged during these work stoppages, according to the SHSP and the prevention measures in place. Systematic verifications are also means of recovery. The development of shared vigilance makes it possible to achieve more in this area. The Stop Work Authority (SWA) and job site shutdown are the last defences against the occurrence of a serious accident.

3.4 The nature of the barriers: the three pillars

It is important to really ask ourselves whether the "three pillars" are taken into account when talking about barriers.

Example

The three pillars, crucial elements of a barrier

In the case of preventing falls from height through the use of a guardrail, we should be asking ourselves the following questions:

- technical safety: what is a technically sound and well fitted guardrail?
- management system: how do we define a rule whereby its installation must be completed with the required time frame? How do we ensure this rule is observed? How do we monitor the actual implementation of this measure?
- human and organisational factors: how do we ensure that the chain of command considers guardrail implementation to be essential and what can managers do to make sure it works and to show that it is very important to them? How can we make sure that everyone sees it as something that is fundamental to eradicate falls from height in the construction industry? How do we make sure that everyone has the right skills: what training system? What sort of training, induction or onboarding will new arrivals to the worksite receive? And what sort of support will be available to new hires?

3.5 Barrier credibility

The guardrail example provided by a company participating in the discussion group illustrates this idea.

First-hand experience of how a barrier can be credible or not

Example

When a barrier is poorly implemented or badly explained, it can become useless. Since a guardrail had been positioned more than a metre away from the potential fall area, operators had to step over it to do their work. To them, the barrier had lost all credibility. It is always important to ensure that the barrier is credible to the frontline workers.

3.6 How the barriers work

3.6.1 The risks incurred by barriers which are likely to malfunction

The barriers are likely to malfunction because they are physical, organisational or managerial constructions. In the worst case scenario, there can be no barrier in place at all because the risk detection and identification system fell short and no effective defence system was implemented.

The actual design of the barriers can also be flawed from the start, as can the methods for monitoring and maintaining their performance.

If the mitigation barrier is weakened, for example, it is the severity of the consequences that will vary. The company thus needs to accurately pre-define what severity means in terms of consequences for the workers and the company.

3.6.2 The effectiveness of the barriers is often tied to their "kinetics"

The barriers must be implemented when the existence of a situation with a high SIF potential has been identified: SHSP scenario. The way in which they are implemented, and later removed from service, is therefore fundamental. It is possible to describe the implementation of a barrier using a representation inspired by the STPA model: System Theoretic Process Analysis [9].

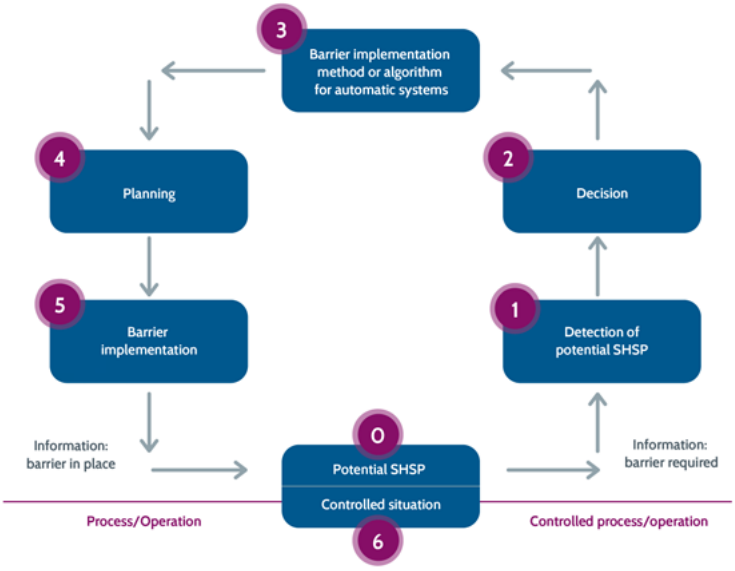

FIG. 12: *Barrier kinetics (the stages of their implementation)*

A barrier is a system with three dimensions: the three pillars of safety. In order for this barrier to be effective, it must be in place when the hazard exposure occurs. This diagram describes the stages of this barrier implementation. It is also the basis of the most important points to control.

In effect, this is a way of describing, in an organised and systematic manner, something that is often simple. But the barrier's implementation or removal from service can require the intervention of several teams or automated systems with appropriate algorithms to function correctly. This process can be disrupted by the organisation or even the technology, resulting in defence system failures.

9. STAMP Systems-Theoretic Accident Model and Process. Leveson, N. (2012) "Engineering a Safer World", MIT Press.

3.6.3 Barrier life cycle

It is important to remember the qualities of a good barrier: robustness, durability, effectiveness, appropriate management and credibility throughout its existence[10].

It is therefore essential to regularly ensure that these qualities are maintained, in order to adapt them to changes in the environment, technology or organisation and to how well they are taken into account by the people in charge of their effectiveness.

Consequently, barrier reviews should be conducted regularly, taking into account any changes to the risks, technology, managerial methods and skills, to ensure they continue to meet safety requirements and to comply with regulations.

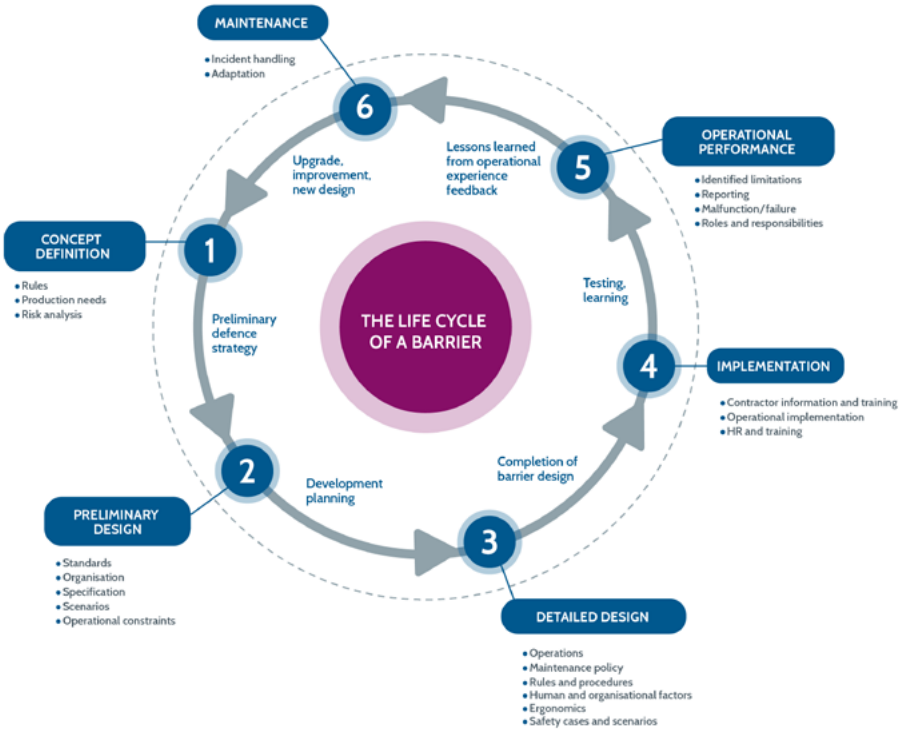

FIG. 13: *The life cycle of a barrier*

A barrier is a system designed by stakeholders wanting to prevent a risk, recover a SIF precursor, or mitigate the effects of an accidental event with a high SIF potential. Like any set of precautions that is designed and then put to use, this system must be monitored, checked, maintained, and modified or replaced if it is obsolete. The "life cycle of a barrier" encompasses the different stages and components of this existence, which must be reviewed on a regular basis.

3.6.4 Example of a defence system failure

Failure of a barrier implementation

Example

While connecting a house to a power grid, a company technician reviewing the situation on site noticed that the trench was too deep and trench support was needed. He called a halt to the work. Some time later, we learned of the death of a contractor company worker who was buried and crushed when the trench caved in, his colleagues having been unable to save him.

This example, which really happened, reveals several flaws in the barrier's kinetics (*see Fig. 11*): installation of trench support to counter the "cave-in risk" (SIF precursor) in a trench due to its depth and the nature of the materials. The high SIF potential criterion "potential energy", linked to the pressure of the surrounding

10. Barrier quality has been the subject of a number of publications. Erik Hollnagel (1995) quoted from "Barriers and Accident Prevention"; pages 97 & 98 (2004): efficiency or adequacy (appropriate for the risk involved), the resources needed for it to work, robustness and reliability, implementation delay, applicability to safety-critical tasks, availability when needed, the possibility of evaluating its performance, the level of dependence on humans.

soil, varies according to the depth of the trench. This significant depth was not detected when the worksite was being prepared.

The stages of the implementation kinetics and the associated failures of the P.R.M. prevention system (see Fig. 12: barrier kinetics)

Example

1. Late detection of the SIF precursor: the SHSP scenario was not detected during the preparation phase. It was revealed when the technician attended the worksite (**SHSP** and recovery situation); the "trench support required" information had not been communicated; the preparation was insufficient;

2 & 3. The recovery failed, despite the technician's warning. Consequently, the **information** regarding the need to install ad hoc trench support came late and the decision was rushed; undoubtedly, the work was not **paused** to consider the conditions for implementation (stop, recovery);

4 & 5. The team was unfamiliar with **the "ad hoc trench support installation" procedure** or did not have it at hand; **the implementation instructions failed**, due to lack of knowledge or training;

6. Prevention failed due to the previous elements and led to installing inadequate trench support. **The situation with a high SIF potential remained.** The decision to work in the trench was made even though the situation still had a high SIF potential.

4

Weakening of the barriers: the disruptive elements and fixes

4.1 The weakening of defences as a result of disruptive elements

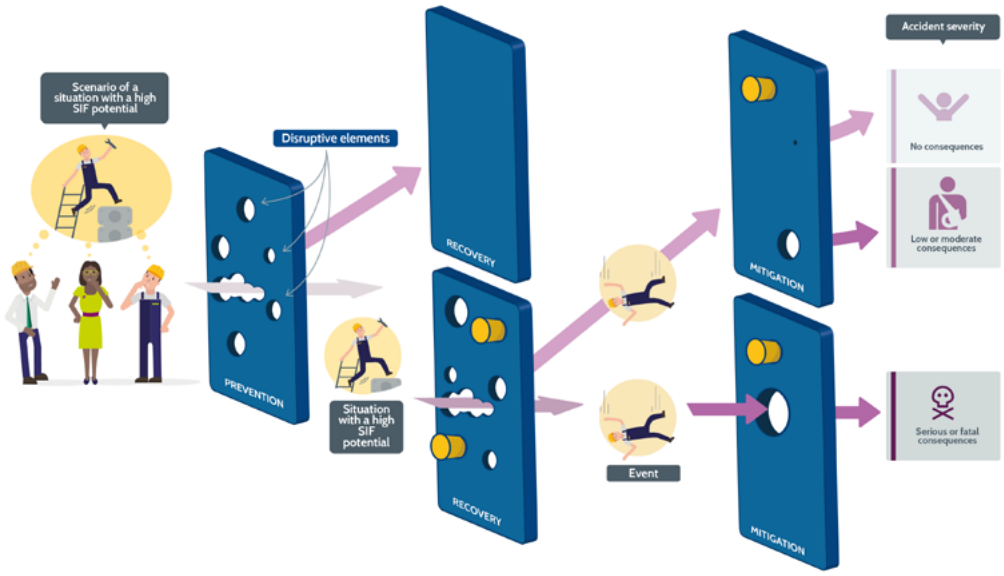

FIG. 14: *Disruptive elements and barrier failures (impairments).*

Based on the SIFP Model, the failures or impairments of the levels of defence composed of barriers are represented by "white holes". If these weak points or a combination of them exist, the barrier will no longer fulfil its role and we will move to a "precursor" state, i.e. a situation with a high SIF potential (SHSP). In the event of a weakening of the prevention level, a HIPO incident, or a weakening at the recovery level, depending on whether the mitigation level is able to fulfil its role completely, partially or not at all, the accident could have no consequences at all, minor or moderate consequences, or serious or fatal consequences.

The discussion group's work highlighted the "**disruptive element**" concept, which encompasses all the factors that can weaken the defence system's barriers.

Disruptive elements and fixes

Definition

A "**disruptive element**" is a phenomenon that will lead to the weakening of a prevention, recovery or mitigation barrier. It may be the technical aspects that are weakened, the safety management system, or the human and organisational factors. The causes of these phenomena must be analysed in order to devise "**fixes**" to neutralise them or limit their impact. Disruptive elements can be chronic or permanent, in which case they are easier to identify and neutralise. They can also be occasional. To manage these, an **effective detection and warning system** needs to be in place.

4.2 The 5 major categories of disruptive elements

The discussion group debates revealed 5 major categories of disruptive elements:

- External: weather conditions (e.g.: storm); climatic, seismic or volcanic event; or stemming from third parties or customers, etc.;
- Intrinsic to the system:
  - Planning/execution: discrepancies between what is planned and the reality of the actions required; improvisation; "making do";
  - Industrial processes, facilities: how well they work; whether they comply with safety standards; frequent breakdowns/malfunctions; reduced performance; process inappropriate for operation, etc.;
  - Management/organisation: conflicting objectives; absence of instructions; rules; poor decision-making; resources/objectives; poor coordination; unsuitable organisation: allocation of duties between departments or workers, relations between entities or with contractor companies, communication, information sharing, etc.
- Direct from individuals: health issues; personal and psychosocial problems; relations with others; actual ability; etc.

4.3 Analysis of potential disruptive elements

Due to their importance, potential disruptive elements must be identified and detected early on to ensure suitable fixes are in place. Operational experience feedback and contributions from all concerned are essential. Examining the processes used to guarantee quality and operational excellence can help this collective identification process:

- execution processes: production, operation, service, etc.;
- support processes;
- management and oversight processes.

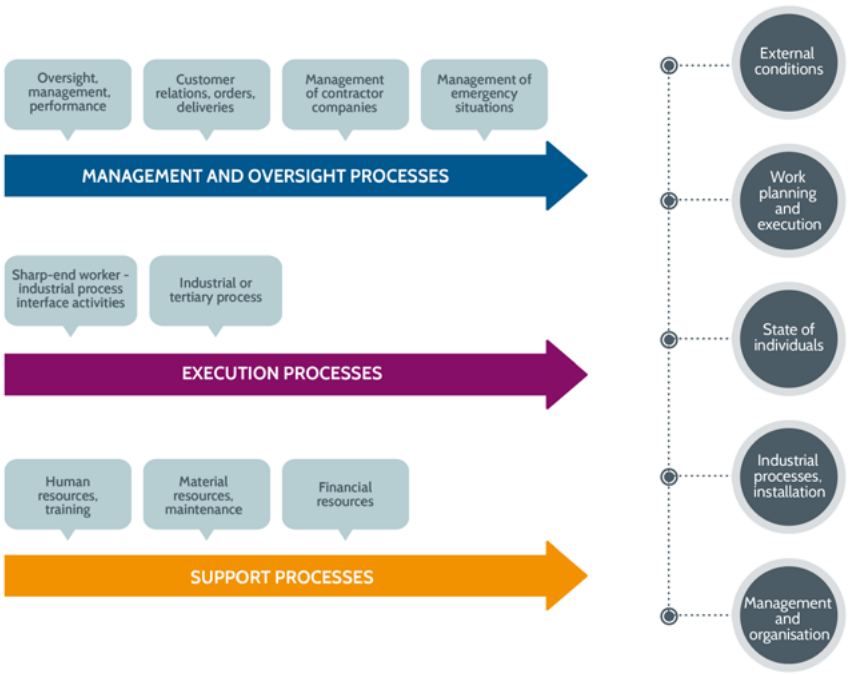

Fig. 15: *Collective identification of disruptive elements based on the processes*

In large part, defences are weakened due to organisation problems. Consequently, by analysing how these organisations function, for example by mapping out the processes that underpin them (operational or execution processes, management

and oversight processes, and support processes), we can identify the main causes of disruptive elements and the measures that could limit their number and consequences.

4.4 The root causes of disruptive elements

Disruptive elements are the phenomena that contribute to weakening the defence system in a situation with a high SIF potential. Finding the causes for these disruptive elements is therefore of prime importance.

The different incident analysis methods can be used[11], but we must insist on the need to take into account the three dimensions of the barriers, including human and organisational factors and all sociotechnical aspects, to choose the most appropriate analysis methods.

The following root cause domains were mentioned by the discussion group:

Example

Possible root cause domains of chronic disruptive elements

Latent factors[12] (*see J. Reason*): general organisation of the entities in question, management, performance management, customer relations, orders and deliveries, management of external contractor companies, management of emergency situations, human resources, training, material resources, maintenance, financial resources.

The root cause analysis will lead to examining, in particular, the trade-offs made between objectives, resources and safety (D. Besnard) as well as cognitive biases (T. Krause)[13]. The decision-making levels are varied. They include top management, middle management, supervisors, the support functions, site managers, the HSE department and the "front office". Cognitive biases can range, for example, from overconfidence (in others and in oneself) to erroneous mental models and the normalisation of deviation...

4.5 Fixes

Definition

Fixes

These are the measures taken to limit the potential effects of known, recurring disruptive elements. A detection system for occasional disruptive elements must be implemented to warn, trigger a pause to think and apply the right fixes for the situation.

It is generally **the combination of several disruptive elements** which renders the defence system ineffective. **With knowledge of the most probable disruptive elements we can devise fixes and design the defence system.** The fixes must target the detection of **combinations of disruptive elements**.

Example

"Three amber lights" system

Some companies have implemented a "three amber lights" system that detects situations in which there is an accumulation of disruptive elements and draws attention when three disruptive elements are combined. The fix, in these situations, consists in stopping work and analysing the situation, then taking any necessary measures before resuming operations.

11. Promé-Visionini, M., (2014) FHOS: l'analyse approfondie d'évènement. The *Cahiers de la Sécurité Industrielle* collection, ICSI.
12. Reason, James T. (1997). Managing the Risks of Organizational Accidents Brookfield
13. Krause, Thomas R. (2016). Bell Group ICSI webinar, ICSI.

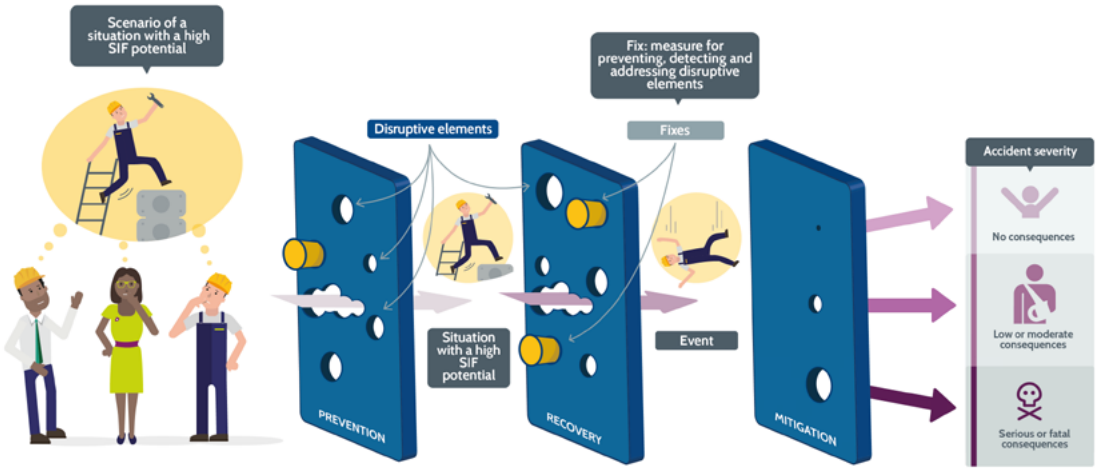

FIG. 16: *The disruptive element fixes of the three barrier levels in the P.R.M system.*

A fix must be in place to eliminate or reduce the effects of each disruptive element and combination of disruptive elements identified, the direct and root causes of which have been analysed.

4.6 Illustration of disruptive elements and fixes

We will use an example of a real accident that illustrates the concepts of disruptive elements and their combination and shows how important the fixes are in preventing these events.

Example

Example of an accident with a combination of disruptive elements

- A young recruit sent to collect a container from a customer's site suffered a fatal accident;
- At the pick-up site, the customer asked the young man if, since he was there, he could load a piece of equipment into the container which had to be positioned on the truck. The young recruit was reluctant to refuse and risk upsetting the customer;
- The young man was found dead inside the container, crushed by the customer's equipment during the lifting manoeuvres;
- His manager had tried to contact him all morning in vain, to remind him to only load the container and not perform any other tasks.

Key point

Incorporating possible errors and unexpected events in the prevention system

Errors or deviations from the established measures are always possible. To the greatest possible extent, these should be incorporated into the prevention system. Events or work conditions can disrupt the smooth running of operations and thus the effectiveness of the defence system.

Knowledge of the reality – in this case a new recruit, a demanding customer who pressures him, and a faulty radio link – is just as important as the general prevention methods. In the example given: the rule of thumb is to stick to what was arranged and not provide any other services (SMS prevention barrier).

Example

Analysis of the combination of disruptive elements

- **The young recruit:** the "external" disruptive element is the customer's request for an additional service. The others are linked to the individual and to logistical and organisational problems, or even lack of training.
- **The combination of disruptive elements:**
  - a young recruit with little experience, newly trained in working the truck's crane;
  - a demanding client, a great deal of pressure;
  - a malfunctioning communication system, no recovery possible.

In the absence of just one of these disruptive elements, the accident could have been avoided. A quick review in the morning during the briefing could have alerted the manager (example of "three amber lights").

- **The purpose of the main fixes is to help prepare people to handle this type of situation:**
  - HOF domain: prepare people to refuse or stop and consult with the manager to analyse the situation; training; safety protocol; prevention plan; review potential disruptive elements during each briefing;
  - SMS domain: systematic implementation of "Customer contract review" meetings, review potential disruptive elements during each briefing;
  - technical domain: ensure means of communication are available (mobile phone, description of rounds, etc.).

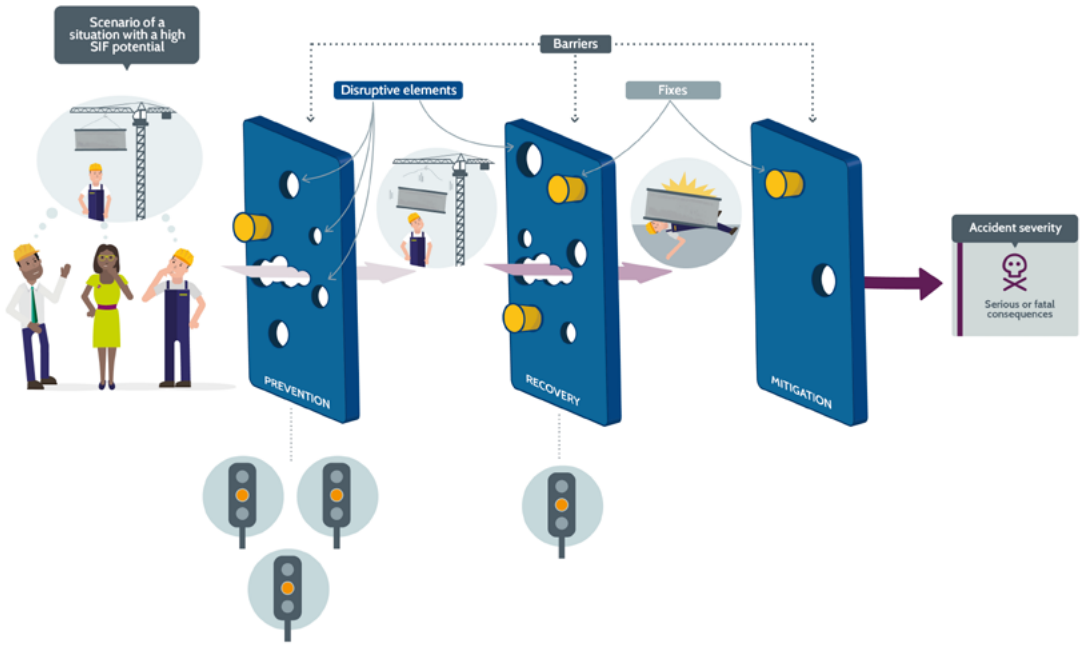

FIG. 17: *The combination of disruptive elements*

Often, a single disruptive element is not enough to weaken a level of defence. The complexity stems from the fact that disruptive elements reduce the effectiveness of the defence system when several of them are combined. For example, a rule breach, an equipment malfunction, a training gap, or a lack of guidance from management. The example of the accident involving the young recruit illustrates this combination of disruptive elements.

5

The conditions for a successful SIF prevention model (SIFP)

5.1 The essence of the debates

To bring to light a new approach specific to addressing serious injuries and fatalities, the discussion group examined the broader conditions required for such an approach to be successfully implemented. Two broad areas were revealed, for which at least a partial reassessment of existing practices was required:

- **the management and its two levels**: local and overall, the indicators, the review and operational experience feedback;
- **the general measures called "prerequisites"**, which will provide a solid foundation for the system, ensuring its effectiveness.

These two points were the subject of important debates and discussions. What emerged is that the situations could vary between companies, depending on the context and the current situation. Often, part of the prerequisites and management methods are already in place. A complete overhaul may not be necessary, as it is possible to draw on the existing and implement any improvements needed for SIF prevention to be effective.

5.2 The two levels of management

Two levels of management, issue reporting and operational experience feedback are needed for SIF prevention:

- **local management**, close to the day-to-day reality at the sharp end, makes it possible to monitor high-risk situations, precursors and disruptive elements, and to make any necessary decisions or take the corrective measures needed to ensure the implementation of SIF prevention. It takes into account day-to-day concrete actions and observations, through briefings/debriefings for example, sharp-end visits, worksite meetings, and the acts that make it possible to identify deviations and monitor the effectiveness of the defence system. It includes the working relationships with contractor companies and external parties;
- **overall management**, which sits at a higher level within the group, company or entity, provides more of a "big picture" view of the implementation of SIF prevention, of general actions – general measures and prerequisites – and of the methods put in place. The design or upgrade of the generic barriers can be initiated at this management level. It is also at this level that it is possible to better consider the complex issues linked to the environment and the fundamental issues pertaining to relations with external parties, including the authorities.

5.2.1 Local management

The **local level** is where there is the most knowledge about high-risk situations, and where the following can best be identified and analysed:

- **real situations with a high SIF potential (SHSP)** and the corresponding accident scenarios;

- **the P.R.M. defence systems (Prevention, Recovery, Mitigation)** best suited for the SHSP, especially based on the generic barriers provided by the overall level;
- the situations where control is lost "**precursors = SHSP**";
- the most frequent **chronic disruptive elements** that weaken the defences, and the corresponding fixes;
- the occasional **disruptive elements** that must be detected and addressed quickly thanks to constant monitoring of the defence system (warning when defences are weakened).

The management ensures that the P.R.M. defence system is in good working order and that the most frequent disruptive elements are neutralised.

"Whistle-blowing" should be encouraged, organised and recognised. Indeed, all information concerning situations with a high SIF potential and the elements that can lead to **SIF precursor situations and disruptive elements** must be reported and addressed, taking into account the facts and realities at the sharp end. Having a great deal of information of different types is very important to guarantee the quality of the local management.

The local level is in charge of the "tailored" aspect of prevention.

5.2.2 Overall management

The overall level is in charge of establishing the generic methods and elements to be applied by everyone:

- **the SHSP scenarios, the P.R.M. defence systems and their barriers, the known disruptive elements and the fixes used**, can serve as a frame of reference to the local levels;
- the **methods for implementing the SIFP system**.

It may need to take care of **the most difficult cases** which cannot be resolved at the local level. Example: the situations that involve the overall level and require decisions on its part.

The overall level is in charge of driving and overseeing the general implementation of SIF prevention and of monitoring its performance and effectiveness over time. Top management is responsible for initiating and supervising prevention, due to the importance it attaches to it. It monitors results and significant events, initiates meetings, requests explanations, and demonstrates its commitment by doing so. The global level must constantly ensure that the system meets requirements, through audits, verifications, and performance management meetings involving the local levels. It advises and supports the local levels in implementing the methods.

On this basis, it tracks indicators (*see § 5.2.4*) that have been established and implemented by the entity as a whole and which afford visibility of the respective positions of the local levels.

It establishes and provides the general measures for effective SIF prevention and monitors them. These measures called "common prerequisites" consolidate the common foundation needed for the prevention system to work. They include, for example, the "Golden Rules" or "life-saving rules", the cooperation measures between client companies and contractor companies, and the just culture. (*see § 5.3*)

The overall level is in charge of the "ready-made".

5.2.3 Local management/overall management coordination

Coordination between the two levels is deemed essential for effective SIF prevention. Properly defining each level's responsibilities is crucial to ensure optimal complementarity.

The local level will focus on the reality of the activities performed and the concrete issues that arise, starting with the identification of SHSP and the design of a P.R.M. system that is fit for purpose. This work is done on a daily basis, in case of changes in the environment or in the conditions under which the activities are carried out.

The overall level is dedicated to ensuring the high quality of the methods and of their implementation. It develops tools, methods, common prerequisites and generic information that can be described as "ready-made" and which the local level then "tailors" to specific characteristics and circumstances.

Each level constantly feeds in to the other and it is important to ensure that these exchanges are optimal.

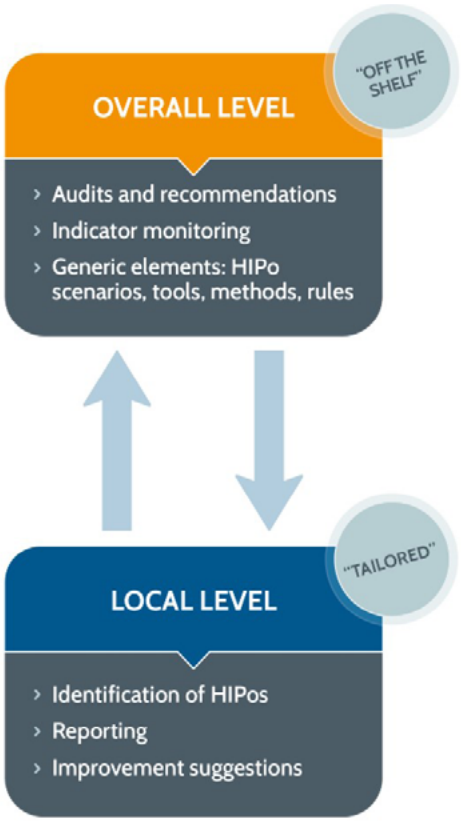

FIG. 18: *Coordination between local level and overall level*

5.2.4 Indicators

Indicators are necessary for performance management, within the company itself and sometimes between companies for comparison purposes and to work together, particularly between client companies and contractor companies.

The discussion group's work revealed the difference between the prevention of serious injuries and fatalities and that of occupational accidents in general. The general indicators – such as incident rate, TRIR, or even severity rate[14] – that take into account all minor or serious occupational incidents (with or without lost time), are not suitable for managing SIF prevention.

An indicator system able to track changes in SHSP control, so that action can be taken, must be better adapted to the characteristics of the company and to the risks in question. The indicators must be appropriate, easily understandable by all, and therefore limited in number.

14. Severity rate: number of lost work days due to accidents per 1,000 x the number of hours worked, with no distinction made between the accidents and the amount of time each worker was off work.

Key point

Categories of suitable indicators

Ineris' presentation of the SPIS (Safety Performance Indicator System) approach led to identifying the main elements to take into account when designing a system of indicators suitable for SIF prevention. Three types of indicators were revealed:

- **result indicators**: these focus on results in terms of accidentology (accidents, incidents, hazardous situations including precursors), but also on the implemented measures that have a direct impact on SIF prevention, such as the state of the essential barriers (compliance with the model and availability when needed);
- **performance indicators**: these focus on the state of the methods in place and progress made in taking into account actions within the company;
- **ecosystem indicators**: these indicators make it possible to track evolutions in the general environment which are important for company transformations and major actions. Example: progress made in developing a just culture or in the budgets, which have a direct or indirect impact of SIF prevention.

One of the most widely used result indicators is the fatality rate per 100,000 employees or per 100 million hours worked. It is especially useful for evaluating major trends in large populations and can only be used by big companies, since the variations are too unreliable for small businesses. Similarly, indicators such at Tier 1 and Tier 2, used in the oil industry or in process chemistry, make it possible to count and track the number of loss of primary containment (LOPC[15]) events that can have immediate or potential consequences.

Since this is a complex system, generally speaking there is no one-size-fits-all indicator ready to be used by everyone and internationally recognised as such. The most potentially serious risks are the ones that lead to the establishment of indicators that are appropriate to the activities.

Example

HIPO indicators for results relating to incidents with a high SIF potential

Some companies monitor trends in "HIPOs" or "High Potentials", i.e. incidents with a high SIF potential. A specific type of organisation is required for this, in order for everyone to really have firmly in mind the concept of SIF potential and the corresponding criteria. The incident may be described as a HIPO from the start at the moment of reporting it, or it can be described as such following its centralised analysis by a committee. "HIPO" indicators allow the tracking of ratios such as the percentage of HIPO incidents resulting from non-compliance with the Golden Rules.

Example

A company's first-hand experience with the prevention barrier performance indicator

The discussion group heard a testimony that perfectly illustrated the idea of using a result indicator to monitor the implementation of a measure to prevent a major SHSP scenario: falls from height on jobsites.

Indicator: the number of guardrails that comply with set requirements.

This indicator was built based on the following observation: implementing suitable collective protective equipment (guardrails) helps to prevent serious injuries and fatalities. The work involved establishing the different values of this indicator precisely, according to the situation observed during inspections. Barrier compliance and completeness (full coverage of the high-risk area) make it possible to better quantify the barrier's relative value and afford a comprehensive view of how prevention is evolving. A certain inspection rate must be respected to ensure the results are credible. Progressively, the indicator not only established itself as essential for measuring prevention performance, it also became a management instrument, particularly where the recognition for results is concerned.

15. Loss of Primary Containment (LOPC) - Global Upstream OGP/API Tier 1 and 2 Classification Guidance 2015.

5.2.5 Two tools necessary for SIF prevention management: reviews and operational experience feedback

The work carried out by the discussion group, and in particular the pilot worksites focused on client company/contractor company cooperation, highlighted the importance of conducting reviews of SHSP scenarios and of the SIFP system. Operating experience feedback following accidental events or the detection of precursors (SHSP), emerged as essential to SIF prevention management. Reviews are necessary, because the mistake often made is to wait for events to happen, without realising that the risks and the P.R.M. defence system have evolved. SHSP change according to the context at the worksites, the operations or the production. As we saw previously, the barriers can behave like living organisms with modifications and impairments caused by undetected disruptive elements, or parts of them may become unsuitable as the risks evolve. This is due to the nature of the barriers (the three pillars) and the quality of their implementation (kinetics).

Through the use of these two tools, described further on, the management becomes dynamic and proactive. It does not wait for the problems to occur. Reviews are a means of examining the system regularly at set intervals or during steering meetings (e.g.: site meeting). Operational experience feedback, on the other hand, focuses on the elements of the SIFP Model and aims to increase effectiveness without getting bogged down in the disparity and variety of causes and thus of the corrective actions undertaken.

The review

It is both a review of SHSP scenarios, so of hazards and risk exposure, and, more generally, of the defence system and its management.

Key point

The three essential steps in a review

1 **Go over the SHSP scenarios** and any new risky situations with a high SIF potential;

2 **For each SHSP scenario, ensure that an appropriate P.R.M. defence system is in place:** the three barrier levels - P.R.M., their natures (three pillars) and their kinetics (all stages) are all fit for purpose;

3 **Take stock of the review:**

- ▷ **Take into account the modifications** that require an adaptation of the defence system;
- ▷ Ensure that **a P.R.M. defence system exists** for each SHSP;
- ▷ Check that **the system is fit for purpose by taking into account operational experience feedback**:
  - The barriers;
  - The disruptive elements and fixes;
  - Local management: ensure the management is effective;
- ▷ Validate **the prevention system and the necessary corrective actions**.

A review should be conducted each time there is a significant change in the general defence system, or on a regular basis to ensure that the defence system is working as it should. Changes requiring a review include:

- ▷ modifications made to processes (including industrial processes), tasks, organisation;
- ▷ changes in the schedule or the coordination of contractors, particularly on major jobsites;
- ▷ the appearance of new risks or situations with a high SIF potential;
- ▷ technical and technological evolutions and associated work methods.

The review should confirm the robustness of the SIF prevention system at a given time. Each review must be documented. Primarily this is to ensure, at the next review, that the necessary modifications have been made.

Operational experience feedback and the analysis of precursors (SHSP) and HIPO incidents

Operational experience feedback is essential to the implementation of the SIF prevention system. It should focus on precursors and HIPO incidents, but also on disruptive elements, their effects and their causes. Because implementing an effective operational feedback experience process is notoriously difficult, it is a crucial step in the design and construction of the SIF prevention system.

As a reminder, the following are crucial to analyse:

- ▷ **Precursors or SHSP:**
  - **Hazardous situations:** Nothing has happened, but the prevention barrier is failing and the situation has a high SIF potential;
- ▷ **Incidents:**
  - **Near miss:** incident with no serious consequences but the prevention and recovery barriers failed. The mitigation barrier worked well;
  - **Accident:** there are consequences for people and/or property; all the barriers failed;
- ▷ **Disruptive elements:**
  - Certain events lead to barrier weakening;
  - Detecting these events and analysing the failure (or lack) of fixes are very important.

Key point

The nine stages of operational experience feedback

1. **Identify the situation with a high SIF potential (SHSP) or "precursor"** and its context and/or the reported HIPO incident;
2. **Identify the P.R.M. defence-in-depth system**, the barriers in place for the SHSP scenario, their nature (three pillars) and kinetics;
3. **Document the control system for the barriers concerned:** local/overall management, roles and responsibilities;
4. **Determine what event(s) generated the SHSP or "precursor", or the incident** (accident, near miss): describe them (chronology, disruptive elements, etc.);
5. **Analyse the defence process and the causes of failures:** technical aspects, SMS, HOF, disruptive elements, fixes, local management, decisions, etc.;
6. **Determine the higher-level failures:** sociotechnical system (internal/external), local and overall management (coordination), lack of prerequisites (see § 5.3);
7. **Determine the stakeholders' contributions to the failures** (support functions, contractor company or client company, third party, etc.);
8. **Draw up a summary of the causes leading to the precursor or the HIPO incident.** Classify them into categories: weakening of the barriers, the fixes, the disruptive elements, the management levels, the higher-level causes, the sociotechnical system, the prerequisites and the various stakeholders...
9. **Identify the lasting changes needed** in order to resolve the failures detected, and organise the implementation of the necessary adaptations: schedule, persons in charge, monitoring, etc.

5.3 The general measures: common prerequisites

5.3.1 A foundation of common actions to embed the SIFP system

These are general actions, common to the entire organisation, that will make it possible to address, among other things, the root causes of the disruptive elements and the overall defence strategy.

To be effective, SIF prevention must be underpinned by general actions focusing on:

- ▷ **safety culture:** just culture, culture of transparency, leadership from the chain of command, a focus on risks with SIF potential, shared awareness of the most significant risks, constant attention to the three pillars, preparedness for crises and the unexpected, shared vigilance;
- ▷ **general actions, in the different areas, concerning the most significant risks and how to address them.** Examples: the existence of shared safety cases about industrial processes, actions to raise awareness of the most significant risks (e.g.: Golden Rules), social dialogue focused on SIF prevention, client company/contractor company cooperation, etc.

FIG. 19: *The attributes of an integrated safety culture*

The attributes of the safety culture represent the priority targets which, if examined in more detail and addressed, will allow a shift towards an integrated safety culture in which everyone is actively committed to the progression of safety[16].

5.3.2 Possible themes regarding the common prerequisites

The current state of the safety culture

The choice of common prerequisites depends on the current state of the organisation concerned.

An assessment is necessary (e.g.: diagnosis of the safety culture).

It is important to survey the situation by examining the various safety culture themes (*see Fig. 19*) and performing a preliminary review of the areas in which it would be useful to initiate actions to facilitate the implementation of an effective SIFP system.

Human and organisational factors: the first area to explore

As a first approach, the discussion group demonstrated that human and organisational factors (HOF) were part of the areas to explore in order to create favourable conditions for the implementation of a SIFP system:

- **organisation, management and leadership:** cultivate trust, motivation from all involved, engagement, shared values, felt leadership, a just culture, Golden Rules, analysis methods, social dialogue, draw up an inventory of the skills and competencies required.
- **the work environment:** "Hawthorne effect[17]", types of working conditions (analysis)…
- **the occupational and work groups:** values, engagement, Golden Rules specific to groups...
- **individuals:** careless mistakes, motivation, trust, necessary skills.

16. Besnard D., Boissières I., Daniellou F., Villena J. (2017). Safety Culture: From Understanding to Action. The Cahiers de la Sécurité Industrielle collection, ICSI.
17. Elton Mayo's studies on the effects of working conditions (lighting) on human behaviour and on teams (groups).

Example

Create a climate of trust

One of the prerequisites most frequently mentioned during the work conducted by the discussion group is the establishment of a "**climate of trust**". This term reflects the conviction that significant and lasting progress cannot be made in SIF prevention unless everyone is convinced that they can speak freely about the events, causes and factors that can lead to serious situations. This climate of trust can only result from implementing the conditions necessary to its creation. Among these, two stood out as most important:

- establishing a "just culture" that makes the rules of the game very clear with regards to positive recognition and to reprimands or punishment;
- devoting time to listen to the people at the sharp end, by scheduling times to do so (pre-job briefing, managerial visits, etc.).

This fundamental work is more specifically necessary to successfully prevent serious injuries and fatalities. Indeed, these more often the result of exceptional circumstances rather than general themes addressed by the standard methods for preventing risks in the work environment.

The necessary prerequisites

It is well worth reviewing the major themes that contribute, directly or indirectly, to advancing SIF prevention.

Key point

"Basic" generic themes have already been identified by the discussion group

- **Leadership:** behaviour of managers, common principles;
- **Golden rules or life-saving rules** to address the most major and serious risks;
- **Client company/contractor company cooperation**;
- **A just culture:** everyone feels that any recognition or sanctions are justified;
- **Safety cases:** when certain industrial processes involve serious and fatal risks, with content that is appropriate for all concerned;
- **Social dialogue:** its acknowledgement of the issue, particularly within the employee representative bodies, and the common attitudes to adopt in this area.

Example

Other "tailored" themes can be explored based on the assessment of the current situation

1. **Anything to do with worker motivation:**
2. **Worker motivation:** arouse interest and get buy-in;
3. **Build trust:** thank people, avoid "reflex" sanctions, show respect, be exemplary, be fair, be authentic, show competency (especially where safety is concerned);
4. **Engagement:** how to encourage people and mobilise them?
5. **The working conditions** and their importance to mobilisation: in what ways are they an obstacle or an advantage? What actions could help further the prevention of serious risks?
6. **Shared values:** how to use them to progress? Example: shared vigilance.
7. **Necessary skills** to acquire: who? why? how?
8. **What rituals?** New or further encouraged? Stop, safety moment, etc.
9. **"Felt" leadership:** what concrete actions and aims? Contact with the sharp end, visible commitment... from the different levels of management;
10. **The groups:** know them (climate, culture, psychosocial status), use their positive influence factors, change the obstacles to serious-risk prevention, lead them, train them;
11. **Careless mistakes:** what to do about moments of inattention? Improve concentration in SHSP phases. Violation or error: be clear, analysis the causes, perform cross-checks...

The general SIF prevention system must include monitoring to ensure that these prerequisites are appropriate and metrics to measure their level of adoption.

Golden rules or life-saving rules

This topic was covered by ICSI in a separate publication from the *Cahiers de la Sécurité Industrielle* collection[18]: "*Implementing Golden Rules*". It provides a good illustration of a general "common prerequisite" type action. An action of this kind requires a preparation and implementation illustrated by the "eight principles" of deployment. Implementing golden rules is a complex undertaking if they are to be more than just an extra layer of the management system. Commitment from everyone and strong drive on the part of management are necessary if the action being launched is to have deep and lasting effects. The *Cahier* elaborated by the discussion group reflects this view.

Key point

The eight principles for implementing golden rules

- **Choose the Golden Rules using a structured and highly participative methodology;**
- **Ensure the rationale behind the Golden Rules is understood and the teams embrace the safety vision;**
- **Train and coordinate a strong coalition for a successful implementation of the Golden Rules;**
- **Identify any obstacles to applying the Golden Rules, address them and organise a solution;**
- **Encourage work group appropriation of the Golden Rules;**
- **Establish and implement a recognition and sanctions policy that is perceived as fair, to ensure adherence to the Golden Rules;**
- **Introduce the Golden Rules for the long term and embed them in the organisation's practices;**
- **Ensure synergy with equivalent contractor-company processes and vice versa.**

Social dialogue and the implementation of a SIFP system

Social dialogue is essential to making progress in SIF prevention, as it helps to ensure that information is escalated, SHSP are handled, explanations are given and discussions take place between the members of the company. In this regard, some members of the discussion group spoke of "social control". In this specific context, control on the part of the social partners means the overall management of the prevention of these accidents. Depending on the type of company and on regulations, it is organised around institutions that are in place for this specific purpose.

One thing that was emphasised was the need to keep in mind that these systems should be used to make progress on the content of prevention without devoting too much energy to the formal aspects and rituals that certain ways of functioning can generate. What is important is to stay close to the reality at the sharp end and prevent the real, existing risks.

Key point

The six priorities of social dialogue where SIF prevention is concerned

- **Shared references in terms of the HOFS;**
- **Refocus the representative body's work on the most serious risks,**
  - *Bearing in mind that "the rest" must be handled properly too;*
- **Consideration of the detail of operations and the reality of the work,**
  - *The various forms of presence at the sharp end;*
- **The just culture: an objective for the employee representative bodies:**
  - *Agreement on the mechanisms for recognition and sanctions;*
  - *Golden Rules that are applicable;*
- **Recognition of the respective roles of management, employee representatives, and the organisations or bodies in charge of safety;**
- **Ensure outsourcing and external contractor companies are given due consideration.**

18. Descazeaux, M., Rebeillé, J.C., Brunel, C., Santa-Maria, D. (2017). Implementing Golden Rules. The Cahiers de la Sécurité Industrielle collection, ICSI.

6

The SIFP Model: an integrated representation of the SIF prevention system

6.1 The essence of the debates

The SIFP Model **summarises what is essential** to prevent serious injuries and fatalities.

This illustration helps to quickly grasp a new way of addressing the issue. It breaks from current widespread practices, because it focuses on SHSP scenarios that have been identified and studied. For each of these, a specific P.R.M. defence system is established, implemented and monitored via two levels of management.

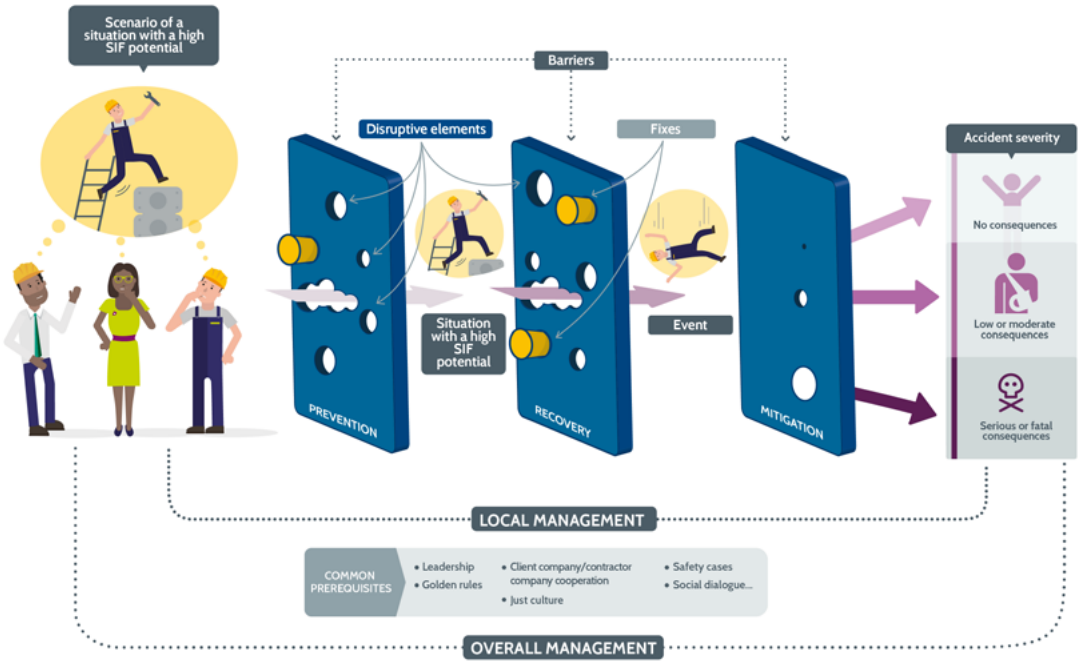

Fig. 20: *The SIF prevention model (SIFP Model)*

6.2 To summarise the SIFP Model, the example of locking and tagging an electrical installation

6.2.1 Example of a P.R.M. defence system: locking and tagging an electrical installation

To really illustrate the model's concepts for the P.R.M. defence system, we can look at the example of a simple electrical installation that needs to be "dead" before work can be performed on it.

Example

Adaptation of the "SIF prevention" model for an electrical installation

The SHSP scenario: risk of an electrical accident on a clearly specified electrical installation which has been locked and tagged for maintenance or repair work: description of the installation and of its limits (shift from generic risk to specific risk following 360-degree view).

Severity potential: electrocution, electric shock, burns. Serious, fatal.

The prevention barrier:

It will involve (*as per the UTE C18-510 standard, for example*):

Step 1:

- Identifying the installation in question and isolating it from any source of electrical energy;
- Locking all energy-isolating devices in the open (safe) position to secure against re-energization;
- Identifying the part of the installation concerned, to be certain that the work will be carried out on the correct installation. All lockouts must be signalled by a clearly visible tag, particularly the energy-isolating devices;

Step 2:

Example: earthing and short-circuiting, if necessary, after proving dead (see recovery barrier below).

Like the two other barriers, it contains three pillars:

- **technical aspects:** installations and equipment that enable the operations to be performed…;
- **SMS:** lockout complies with the standard (e.g.: UTE C18-510) for the installation's voltage… verifications, audits;
- **HOF:** skill (accreditation), leadership: major electrical risk, managerial involvement…

Precursor (SHSP): "still energised after step 1 of the lockout/tagout process"

The recovery barrier: checking the installation is deenergised, using an approved device that has first been tested on a live installation.

- Prove dead;
- If there is still energy present: this is a situation with a high SIF potential (SHSP), a precursor to an electrical accident. Work should be stopped and the tasks performed to implement the prevention barrier (kinetics) should be checked. The electrical permit-to-work can only be issued once the installation in question has been proven dead and, if the circumstances call for it (one-step lockout), after grounding and short-circuiting.

Event: short circuit, flash, with potential impact on the worker or other operational staff or third parties.

The recovery barrier: personal protective equipment (PPE). Examples: insulating hard hat, hard hat with a safety visor to protect against molten particle projections, eye and face protection, insulated gloves, insulated shoes, protective insulated clothing, but also, depending on the installations to lock out, insulated stool or mat.

6.2.2 Example of two levels of management for electrical risk

Example

Local management: the goal will be to continuously ensure that lockout/tagouts are performed according to instructions and safety requirements, but also, that permits-to-work are issued in due course for the work can be carried out. This management level is therefore in charge of ensuring that the appropriate means and necessary skills are available to achieve this goal. Disruptive elements stemming from organisational, planning and installation compliance issues can affect the reliability of the defence system. They should therefore be monitored as part of this management.

Overall management: this consists in ensuring that the implementation of the P.R.M. defence systems in the various entities complies with safety requirements and that the local management level is properly tracking performance (*delivery of compliant lockout/ tagouts within the expected time frame...*).

In particular, through verifications and audits and working with the Purchasing Department, those responsible for designing the facilities and others, it controls the system for delivering and managing electrical accreditations, as well as the compliance of facilities, equipment and instruments. It tracks any indicators established for the corresponding generic risk.

Part Three

The client company/contractor company relationship

1

Working towards the client company/ contractor company cooperation needed for SIF prevention

1.1 Why the discussion group chose this theme

The client company/external contractor company (CC/ECC) relationship is essential to preventing serious injuries and fatalities. Most companies find themselves in the CC/ECC relationship situation because they work for clients whose facilities can present risks, and others outsource activities which they have a duty to oversee. More and more companies are incorporating the safety performance results of external contractors into their own results. Serious and fatal accidents frequently occur in outsourced activities for the reasons outlined in Part One.

"Contractor company" should be taken to mean any company that is external to the client company but involved in its activities in some way. Indeed, suppliers often attend their clients' facilities to deliver products. The client companies themselves can deliver waste to contractor companies in charge of waste treatment, for example. The activities are then closely interlinked and dependent on the sites and their environment. For this reason, it is necessary to take into account the relationships as a whole and the different types of contracts and of mutual risk management for all the categories of services, in order to tackle joint SIF prevention.

The interrelationship between the activities of both parties is such that it is difficult to determine what part each plays in the causes of accidents.

For all these reasons, the discussion group considered this subject to be one of the four major themes to examine. Several members are predominantly in the role of contractor and frequently in the role of client company and vice versa. It is quite clear that things are completely interdependent. In addition, part of what was learned by studying the CC/ECC relationship can be applied to the relationships between the various entities of a same company (engineering/operations/maintenance).

1.2 The need to move beyond the usual contractual relationships

1.2.1 Joint actions to implement

The debates revealed the need to move towards cooperation between client companies and contractor companies to make progress in SIF prevention.

This close cooperation must result in joint actions between client company and contractor company.

Key point

Joint actions are necessary beyond what is contractual

- **The joint display of a strong will to prevent serious and fatal accidents**, contributing to the expression of joint leadership;
- **The implementation of a coordinated, or even shared, system of recognition and sanctions**, to create a culture that both parties perceive as just;
- **The identification of the situations posing the most serious risks** on the worksite or in an operation, and **agreement on the barriers put in place**;
- **The identification of the common latent factors**, which are potential causes of accidents, with a focus on the most important coordination and interfaces;
- **The implementation of SHSP scenario detection** through transparency, the right and duty to point out hazardous situations and unsafe behaviours, and shared vigilance;
- **The organisation of a joint management system and generalised operational experience feedback.**

1.2.2 Building cooperation: 4 themes and 10 questions to ask

Since there is a need to move beyond the usual contractual and regulatory relationships to ensure that SIF prevention is effective, 4 themes emerged as important and insufficiently taken into account in current practices. The non-exhaustive list that follows is an example of questions that were put forward by the discussion. These should be asked to reinforce the cooperation.

Example

Questions to ask in order to improve cooperation

The general prerequisites:

- Make SIF prevention very clear in the contractual relationship;
- A common frame of reference: common measures for preventing serious and fatal accidents;
- Ensure everyone is familiar with these measures, introduce operational experience feedback and continuous improvement in these areas.

The right and duty to call things out

- Motivate and train contractor company workers to dare to transcend the usual barriers of the client company/contractor company relationship;
- Encourage client company representatives to commit to this new relationship;
- Establish the three steps: raise the alarm, call out the situation, stop work if the risk is serious or the golden rules cannot be applied.

Transparency

- Ensure that information is duly reported and there are no obstacles to this, encourage everyone to practise transparency and to speak up.

Shared vigilance

- Encourage sharp-end workers to help each other;
- Develop a mutual vigilance strategy.

1.3 The lessons learned from the pilot worksites

For the client company/contractor company relationship theme, the discussion group conducted pilot tests on sharp-end operations linked to contracts involving series of operations and on worksites at industrial facilities. These pilot sites provided information about the CC/ECC relationship and on how and what methods to use to tackle this.

1.3.1 The points warranting special attention

The shared vision of serious accident risks

If *the vision of serious or potentially serious risks* is not shared, mental models sometimes differ and there is a risk of non-coordination or even non-cooperation where prevention is concerned.

Discrepancies appear internally based on the visions of the different occupational groups, on both the client company and the contractor company's side, but also between the two parties.

The nature and content of contact with the sharp end

It is important to keep up contact with the sharp end, because it is often at this level that the major safety decisions and trade-offs are made.

This contact should include: sites meetings, managerial safety visits, preliminary inspections, handling of pause & checks, issue reporting and its follow-up, the answers given.

Contact with the sharp end brings valuable lessons for understanding the level of transparency and the types of concrete "micro-decisions" made on the frontline (*e.g.: additional cost of signs taken into account or not, additional cost of implementing effective methods for indicating underground structures*). Safety/resource decisions are often made at these levels, but the actors are not always aware of the implications of these decisions.

Example

The preliminary inspection

Holding a meeting on site with the client company's project manager, the contractor company's preparation supervisor and a municipal representative ensures that any worksite constraints not brought to light in the study are taken into account, and contributes to preventing potentially serious risks:

- the position of an installation can be revised to take into account traffic-related risks and the slope gradient for the positioning of the machinery: overturning and load lifting risks;
- the need to switch to "directional drilling" to take a narrow path can be taken into account, as can the risks tied to machinery and third party networks;
- single-lane alternating traffic flow can be requested to prevent traffic-related risks for workers and third parties.

The contractual relationship

It has a great influence on behaviours at different levels. The cost/time aspect is often major. Failing to highlight the importance of SIF prevention in policies and contractual clauses is undoubtedly detrimental to the implementation of prevention.

The different decision-making levels

Time must be spent analysing the decision system that underpins the CC/ECC relationship. Beyond what is agreed in the contracts and policies, it is at this level that a better understanding can be gained of the factors that will influence decisions and each person's role in this area. It is important to keep in mind that each party has an interest in optimising the cost/quality/time triad.

Contact occurs at different levels of the organisation structures of companies. Its nature must be analysed specifically.

- Regular contact at the sharp end between the operational teams (team leader, project manager, worksite manager): it is often pragmatic, aims primarily to progress the work or joint operations and requires daily decision-making whose impact on safety warrants further and more detailed analysis.
- Regular review sessions between higher level managers to keep up to date with several worksites: progress made, handling of any reported issues and sometimes scheduling or financing decisions (stop work) or sanctions in the event of repeated problems.
- Other stakeholders, such as the purchasing or accounting departments, can contribute to the decision-making process. The consequences on SIF prevention and safety must be analysed, since at their level they do not always have sufficient knowledge of the reality at the sharp end.
- Relations with other important stakeholders: this is particularly the case for those in charge of running and operating facilities or networks, and for planners and schedulers, who grant access authorisations and initiate the LOTO processes for the parts of the installation on which the contractors will be working. The issuing of access authorisations and the performance of the necessary operations are crucial for safety and for SIF prevention. LOTO delays and durations, for example, especially need to be analysed because they can be a source of disruptive elements that can weaken the prevention, recovery and mitigation barriers that protect against serious and deadly risks.

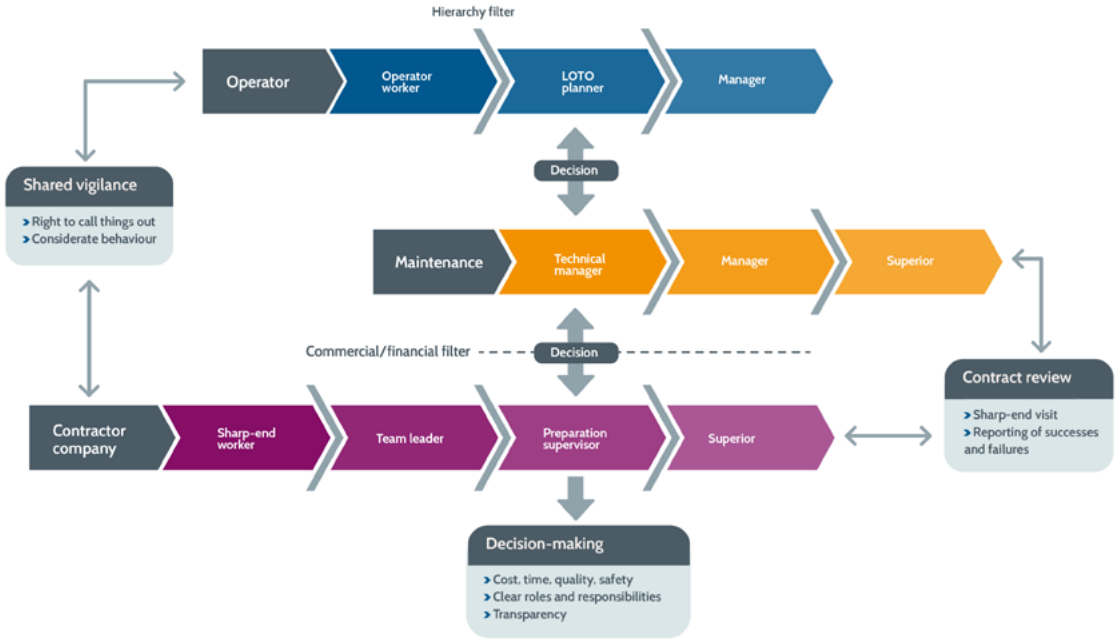

FIG. 21: *Example of an analysis of different decision-making levels within the CC/ECC relationship*

Using an example from a pilot worksite run for the discussion group, figure 21 illustrates the complexity of the decision-making levels based on the usual relationships between the various parties involved and the reviews organised at the higher levels. The roles and responsibilities for decision-making must be reassessed based on skills, familiarity with the reality of the work (transparency, presence at the sharp end) and the principle of subsidiarity.

The "common safety culture construct"

Without a doubt, one of the important lessons to have emerged from the pilot worksites conducted by the discussion group is the concept of a "common safety culture construct".

Sharp-end observation reveals the level of shared understanding of the worksite problems or of the day-to-day activities and all related safety aspects.

Without this sharing of the ways of doing and thinking, there is a risk that some of the aspects of SIF prevention will not be taken into account. Although they are very important at times, regulations are not enough to guarantee this shared awareness[19].

19. FonCSI working group focusing on "Balanced Contractual Relationships", publication coordinated by Eric Marsden (2018). Partage des modèles de sécurité entre donneurs d'ordres et entreprises intervenantes (in French - English version not yet available). The Cahiers de la Sécurité Industrielle collection, FonCSI.

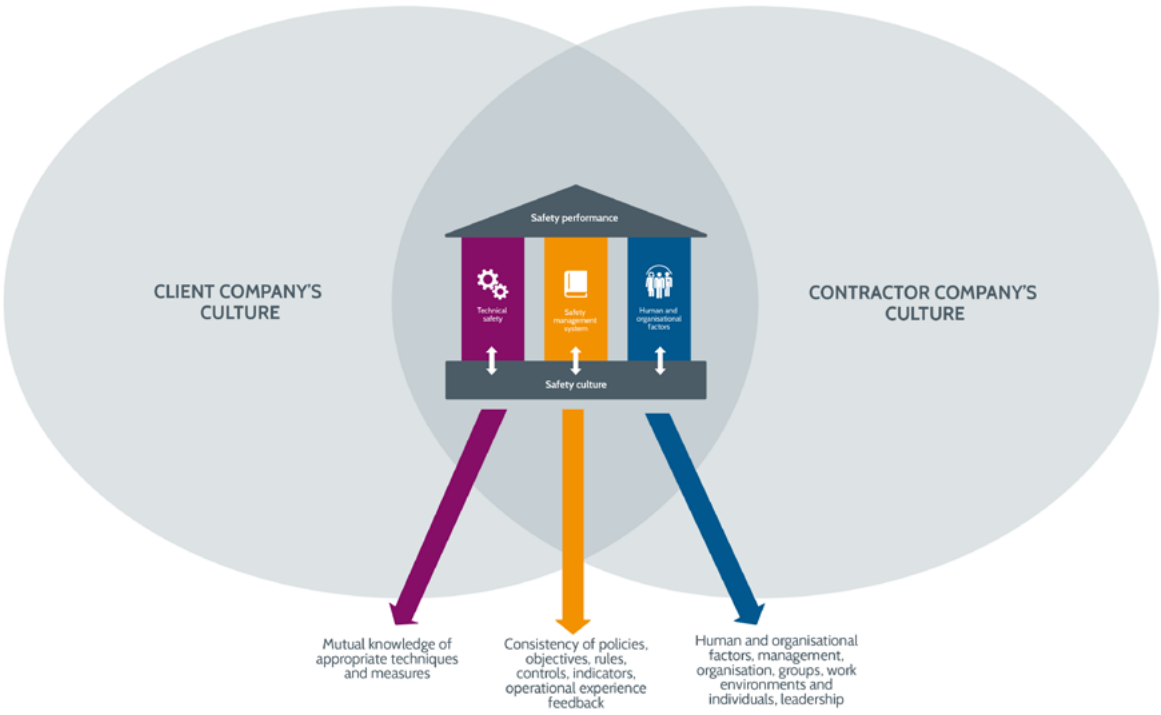

FIG. 22: *The common safety culture construct between client company and contractor company*

Key point

The safety culture approach: the common construct

It begins with the realisation that having established rules and standards in place and letting everyone know the order in which to apply them is not enough to stop accidents, particularly serious and fatal ones, from occurring. There also needs to be a common culture in place to trigger the right reactions and encourage the right decisions to be made on both sides (client company and contractor company). It is only then that, depending on the circumstances, which are not always predictable, there will be constant control of serious risks.

The **three pillars of safety** – technical aspects, safety management system and human and organisational factors – make it possible to ensure that a common culture exists between the two partners and that this is sufficient to build mutual understanding on solid foundations.

To illustrate this, it is important to focus on the P.R.M. defence system and the barriers, as these are major elements in SIF prevention.

Example

The technical aspects pillar

An example to illustrate this point: to guarantee safety, it is essential to earth high-voltage electrical installations on which work is to be performed. Yet we know that things can go wrong in the process: inappropriate positioning, incorrect sequence followed, or no safety flags in place... The technical aspect (and understanding the physical phenomena that explain it) is therefore a first important element of the "common construct". Hence, it is important for both the client company and the contractor company to understand the potential risks generated by the equipment, machinery and operating methods of the other party, and to agree on this shared vision.

The safety management system pillar

Example

This covers all of the "rule-based" aspects between the two partners. It includes the management of contracts and of safety-related aspects, but also the important rules (including the Golden Rules and harmonising them when those of the two parties differ), the common rules about incident reporting and handling, the control and operational experience feedback processes.

The CC/ECC relationship is very much linked to the procurement policy. The latter is evolving and increasingly taking safety into account. But it appears that companies do not always see or understand this link. There is significant work to be done to ensure that, more specifically, the evaluation and recognition criteria relating to SIF prevention are properly integrated into the system and understood by all.

The human and organisational factors pillar

Example

Often, organisational factors play a major role in the causes of serious accidents. Consequently, it is important to ensure that the assessment of the current situation does not reveal any major problems: insufficient coordination between departments with different missions, incomplete information, training system, professionalism and timely updating of documentation. It is crucial to ensure that the importance of SIF prevention is properly understood and championed by the two chains of command. The top managers right down to the sharp-end supervisors must demonstrate leadership and be exemplary, including when making decisions and trade-offs, they must recognise improvement initiatives and the reporting of information – including errors, and they must carry through any required analyses and corrective actions.

Certain concrete actions will clearly demonstrate their determination: joint safety visits by management and joint analyses of SIF precursors (SHSP), disruptive elements and accidents.

Through joint management, the chain of command of both parties (client company and contractor company) must ensure that the SIF prevention system is applied and effective, and that efforts are being made to improve it.

2

Client company/contractor company cooperation: a fresh approach

2.1 The complexity of the CC/ECC relationship

The complexity of the client company/contractor company relationship explains the difficulty in obtaining quick results in SIF prevention. It stems from the fact that this relationship is "manifold" due to the variety of people who can play a role in it and also because of the diversity of sometimes conflicting constraints weighing on them. These include regulatory obligations, technical requirements, cost and time, service quality and all aspects associated with the environment, third parties and the authorities. Safety officially has a prominent place within this network of requirements and obligations, but it is important to be realistic: trade-offs with the other constraints are inevitable and possible at every level of the relationship.

2.2 The traditional view of the CC/ECC relationship

The discussion group's work led to studying the CC/ECC relationship by looking at how it unfolds chronologically, whether an individual contract is involved or global contracts for a range of services (maintenance, routine work, repairs, etc.).

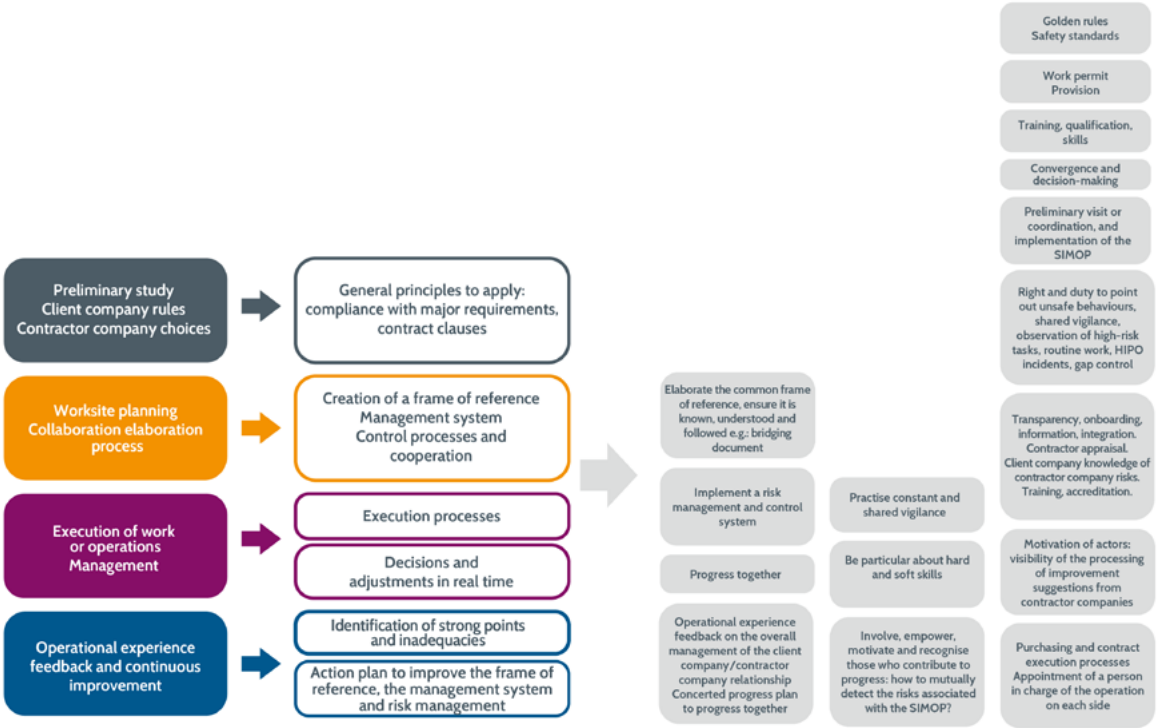

FIG. 23: *The chronological approach to the CC/ECC relationship*

The points to follow as the business relationship unfolds

Example

These concern SIF prevention, either through stated policies, requirements in RFPs, the examination of business proposals, the bidding companies' qualifications and their evaluations, or through more concrete actions throughout the business relationship, such as:

Identifying SHSP scenarios and taking into account the P.R.M. defence system from the planning stage onwards:

- Planning: scheduling, LOTOs, SIMOPS, design of works;
- Preliminary visit (maintenance, operations-project, contractor company): discussions about SHSP and the measures put in place, prevention plan;
- Worksite preparation: opening meeting, finalisation of schedule, review of SHSP scenarios;
- Specific CC/ECC agreements: health and safety coordinator;
- Execution: drafting of the Work Order, permit to work, lockout/tagout, site meeting;
- Progress meeting, risk review, schedule update, etc.;
- Project review and appraisal of the company, taking into account SIF prevention.

Additionally, it is important to highlight **the essential points of SIF prevention that must be observed** while the work is underway and the fundamental and well-established elements **that will serve as a reference at each stage**. These points, such as the safety policies or the procurement and training policies are **common prerequisites** that must be analysed in order to develop a solid understanding of the possible causes of disruptive elements and thus of the weakening of the defence system. The role of the entities in charge of procurement and of relations with contractor companies and suppliers is major. Therefore, their involvement in SIF prevention is absolutely necessary and should be aligned with the general measures adopted. Their influence on each stage of the business relationship must be analysed.

The local management and overall management concepts must also be put into perspective with the stages of the project or the series of operations. At certain very specific stages, it is important to ensure that these two levels of management are effective and coordinated in a manner that is consistent with the usual pace at which the technical and financial aspects of the business relationship are handled. It is also important that they include regular work completion reviews with the participation of all stakeholders, in order to gather key elements essential to managing SIF prevention.

2.3 Approaching the relationship from the perspective of the SIFP Model

The SIFP Model summarises the various points that can lead to effective SIF prevention. Starting with this model is therefore necessary in order to properly identify the points requiring a shared vision and the areas where increased cooperation is a must.

Study method using the SIFP Model

Key point

The state of play is determined thanks to different forms of contact during the pilot: individual and group interviews, participation in meetings, looking over documents, and sharp-end visits. Of prime importance is having the model in mind and really considering each of its elements: SHSP scenario, barriers, SIF precursors, disruptive elements, their causes and fixes, HIPO incidents, the local and overall management levels, and the prerequisites.

It is important for both the client company and the contractor company to have as similar a vision as possible of the model's components.

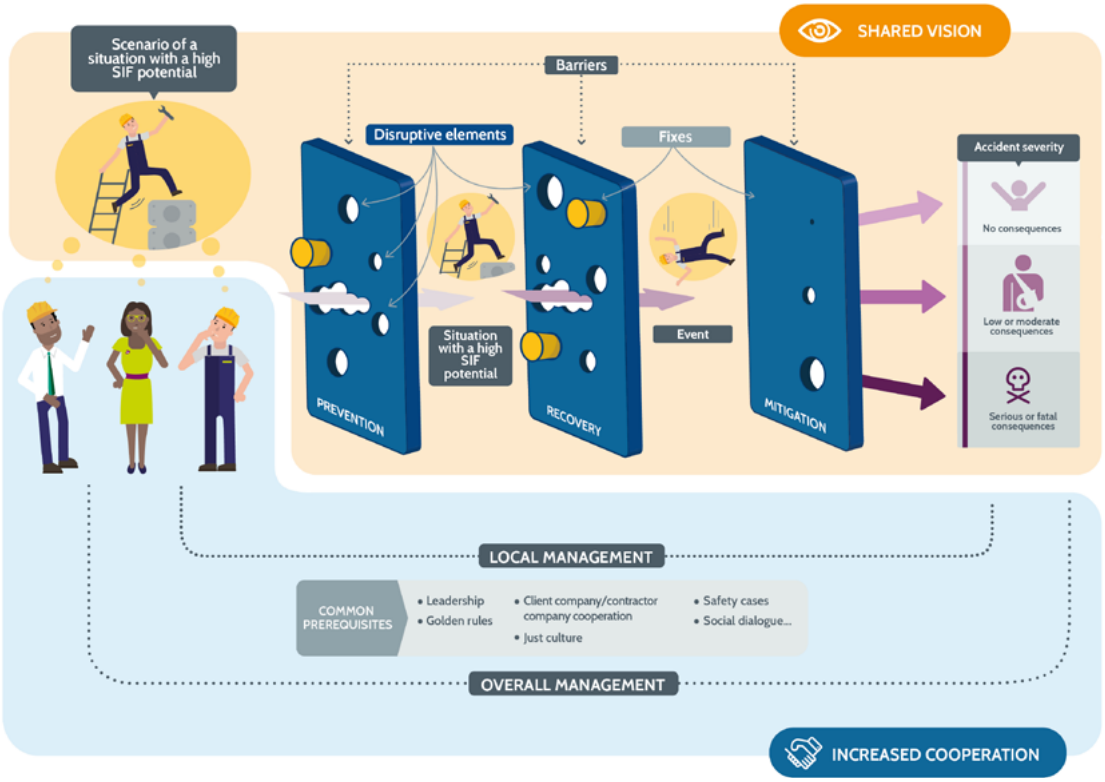

FIG. 24: *Shared visions and increased CC/ECC cooperation around the SIFP Model*

A shared vision of the different SIFP Model elements is very important to make progress in SIF prevention. There must be increased cooperation in the way of managing this prevention, locally at the sharp end, and at the top management level of both partners.

Key point

Shared visions and increased cooperation

First, the SHSP scenarios established based on scenarios of potentially serious accidents gathered from operational experience feedback or from hypotheses of situations with a high SIF potential which are conceivable even if they have never yet occurred.

Second, the Prevention, Recovery and Mitigation (P.R.M.) defence system. These barriers must be known and implemented, often by both parties, in a coordinated manner. It is therefore essential to ensure that the vision is shared and that the barriers are properly in place.

A mutual understanding of the SIF precursor or SHSP and disruptive element concepts is paramount. Indeed, both parties must be able to detect precursors (real situations with a high SIF potential), and to analyse the causes for which they are each and sometimes both responsible. They must do the same for disruptive elements in order to understand why they happened and to address them, by stopping the work and making the required decisions.

Greater cooperation between the two parties is needed for joint actions:

- identifying SHSP scenarios and performing the necessary reviews to update them (management or site meetings, for example),
- searching for causes following an SHSP, a disruptive element, a HIPO incident or an accident,
- local management and operational experience feedback, when joint decision-making is necessary, or even overall management for all aspects relating to method adaptation and to the analysis of recurring and complex problems. This can be reviewed during annual meetings with the companies;
- common prerequisites such as demonstrating joint leadership with regards to SIF prevention, recognition and sanctions, reciprocal information exchanges about risks, and adjusting the Golden Rules together to arrive at a shared vision.

2.4 The CC/ECC relationship from three perspectives

The pilot worksites revealed the need to use three approaches simultaneously to properly analyse the strong and weak points of client company/contractor company cooperation to prevent serious injuries and fatalities:

- The SIFP Model
- The common culture construct
- The chronological approach

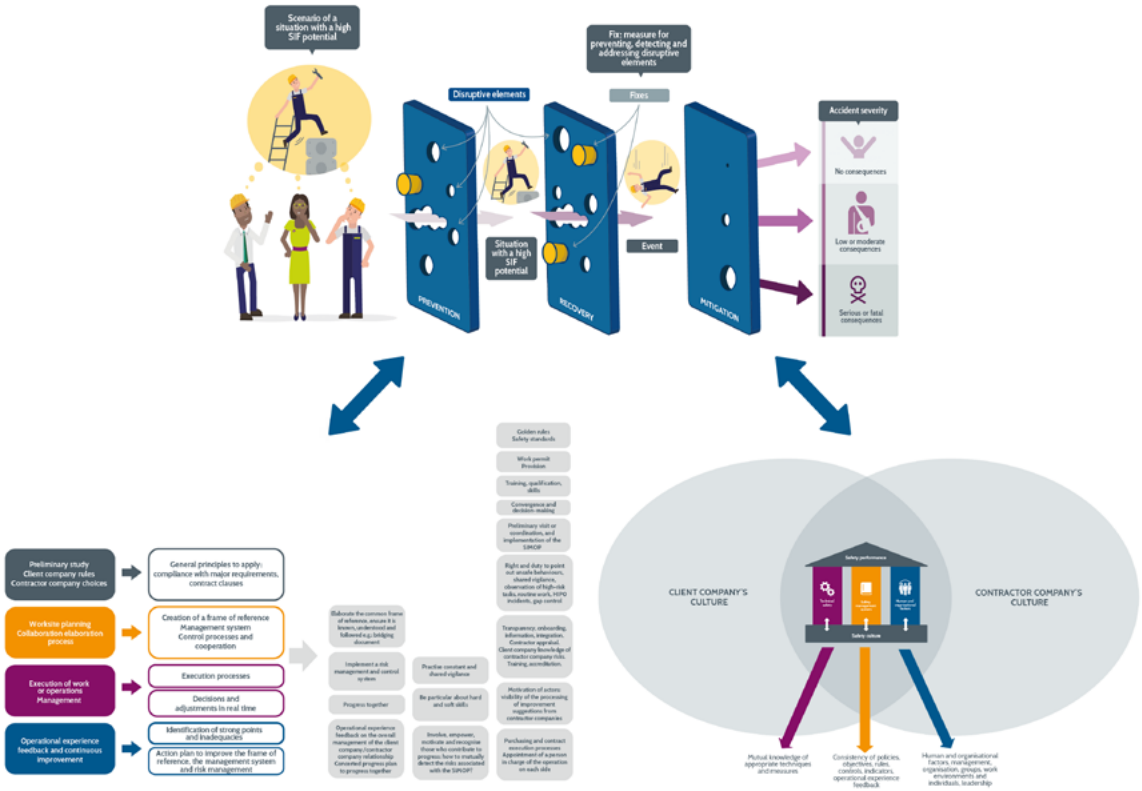

FIG. 25: *The three complementary approaches to CC/ECC cooperation for SIF prevention*

By combining the three approaches, the state of the relationship between the client company and the contractor company can be assessed and the necessary improvement actions can be developed.

2.5 The frame of reference for CC/ECC cooperation

The study conducted on the pilot worksites revealed, based on the "three approaches" to the client company/ contractor company relationship, a frame of reference for evaluating CC/ECC cooperation for SIF prevention. It can help to diagnose a situation and monitor improvement actions.

Reference framework for CC/ECC cooperation

Key point

- **Identifying SHSP scenarios:** What common method? What common vision?
- **A shared vision of P.R.M. defence systems:** What is the role of the CC and ECC respectively?
- **Detecting and monitoring SHSP and HIPO incidents:** What common reporting and handling?
- **Detecting and monitoring disruptive elements and fixes:** What common method? What common vision?
- **Local management:** Monitoring of SHSP and P.R.M. defence systems. Joint reviews and joint operational experience feedback?
- **Overall management and the common prerequisites:** What relationship monitoring, joint discussions?

- **The common safety culture construct:** Ensure that the three pillars are balanced in the cooperation;
- **The important steps in the stages of the business relationship:** Consideration of SIF prevention when reviewing qualifications, RFPs, common rules, contracts, reviews, contractor company appraisals and remuneration.

2.6 Building CC/ECC cooperation for SIF prevention: examples of observations and avenues for improvement

Using the frame of reference, it is possible to assess the current state of the CC/ECC relationship and build a plan to increase cooperation. The examples are taken from the information gathered at the discussion group's pilot worksites.

2.6.1 Assessing the current situation

Based on the eight major themes of the frame of reference, the different points of the current situation assessment reveal examples of possible anomalies, gleaned from observations at the pilot worksites.

Shared common visions

SHSP and identification methods

Example

Gaps are often due to the use of generic lists of risks in regulatory documents, without taking into account SIF potential. There is a lack of precision when it comes to real-life situations, which are often combinations of risk factors: intervention on the industrial process, presence of moving vehicles or machinery and SIMOPS being carried out by several teams. This is compounded by limited discussion during joint inspections, sometimes conducted in the absence of those most affected, and few updates during site meetings.

The P.R.M. defence systems

Example

The measures taken to prevent risks are often described rather generically in the regulatory documents established by contractors. There is no distinction made between the three levels of defence, P.R.M. The description of the barriers is limited to the measures to be taken, described in rather general terms. This without explicitly taking into account the technical aspects (mutual knowledge), the common safety management systems (SMS), and the human and organisational factors such as support and assistance, managerial communication and involvement (safety visits, decision-making processes), etc. The prevention plans are examined by the client company.

Necessary joint actions

Detecting and monitoring precursors or SHSP

Example

Precursors are situations with a high SIF potential which are often "recovered" during operations and seldom reported in order to be addressed. There is no specific common process in place to motivate workers to detect and report them. The criteria for severity potential are established by each party (e.g.: more than 3 months of lost time for a contractor), rather than there being a common standard. The client company and contractor company are aware of certain issues, but this is more thanks to personal initiative (e.g.: report that energy is still present following a stored energy check), or to findings during safety visits, regarding SHSP that have likely occurred (e.g.: worker not secured during work at height). In general, there is no detailed joint analysis carried out for these SHSP. The CC and ECC each have their own separate system for reporting hazardous situations. One exception is the HSE department, which is progressively sharing part of the information in its possession.

Detecting disruptive elements, devising and monitoring fixes

Example

There is no common system in place for detecting disruptive elements and devising fixes. Certain phenomena are known (delays in releasing from lockout/tagout, unplanned site access, teams performing unexpected operations in the work areas). However, these are addressed on a case-by-case basis rather than collectively. The fixes are not devised jointly, although initiatives are gradually emerging to address recurring problems. Contractors often hold back on voicing these problems. Site meetings do not systematically include a review of disruptive elements encountered and fixes.

Local management: regular reviews, operational experience feedback

Example

The management is not organised to focus on serious risks. There are no systematic reviews of SHSP scenarios, for example during the site meetings held on a regular basis. As a result, new risks, precursors and disruptive elements are not always brought up and problems stemming from failures or deficiencies in the P.R.M. defence system (incomplete demarcations, unsuitable traffic management plan with the presence of machinery in a pedestrian lane) are not always analysed.

Overall management and the common prerequisites

Example

The issues reported to the next level of management concern both the quality of the work produced and safety problems. Issues of all kinds are reported and are not classified according to their severity potential. There is no specific indicator for SIF prevention. Therefore, it is difficult to know its current status and whether or not the measures taken are effective. The general measures, common prerequisites, are not focused on SIF prevention. There is a tendency to give more and more importance to safety in contract policy, particularly by granting contract bonuses to those with the best results. This system is not yet very clear for companies, but it does not especially target the most serious risks and their prevention. Common themes, such as the just culture, were not discussed.

The common safety culture construct

Example

Action should especially be taken on the HOF pillar. The two other pillars, namely the technical aspects and the safety management system, are less problematic. The common technical culture and familiarity with the facilities are strong. The management system is structured, even though it does not specifically address risks with a high SIF potential. The areas where actions are lacking are leadership and the clear demonstration of a common determination to prevent serious injuries and fatalities, through symbolic acts such as joint safety visits (start of implementation), conducting joint analyses of accidental events, and strong and coordinated communication on these topics.

The important steps in the stages of the business relationship

Example

In the different stages of the business relationship – from the RFP to the selection, the inspections, the launch and preliminary coordination meetings before the important phases, the site meetings until completion of the work – there is no company evaluation or recognition of the results of specific SIF prevention measures. Even though safety is now being given increasingly more importance in certain phases (selection and evaluation, for example), and joint site visits focusing on safety are gaining ground, these actions are not focused on risks with a high SIF potential.

2.6.2 Analysis and improvement actions

As the previous example shows, by drawing on a diagnosis based on the eight themes covered in frame of reference, it is possible to rather quickly identify the points requiring improvement actions. These actions must take into account the type of outsourcing. With permanent or frequent outsourcing it is possible to initiate actions over the medium and long term. Occasional contracting requires actions which are more focused on the essential requirements of the work involved.

2.7 Summary: CC/ECC cooperation

The client company/contractor company relationship is generalised to numerous activities. Consequently, it must be completely and systematically incorporated into any SIF prevention system.

To progress in this area, there is a need to go further than the usual contractual relationships and simply applying safety regulations. It is essential to have a more open and cooperative relationship enabling people to speak freely and honestly about any problems encountered. To achieve this, there needs to be greater transparency at all levels of the company, shared vigilance, and a duty to call out potentially serious situations. This type of change cannot be decreed; it requires a total commitment on the part of both CC and ECC management. The discussion group's debates and the pilot worksites focusing on this topic revealed certain specific points that are necessary to ensure progress.

Areas for improvement

Key point

- **The attention that must be paid to the different situations where decisions and trade-offs are required;**
- **The state of the "common safety culture construct"**, through the three pillars of safety, will be essential for influencing worker behaviours and initiative-based safety;
- **The adaptation of the contract policy** in order for it to truly take into account SIF prevention, particularly for anything relating to appraisal and recognition;
- **The integration of the specific SIFP approach into all the important stages** of the business relationship, particularly anything to do with safety management: reviews of the SHSP scenarios common to both parties and of their corresponding defence systems.

The study of the CC/ECC relationship requires an three-dimensional approach

Key point

- The approach based on the SIFP Model will emphasise the common visions or the gaps and the joint actions to increase;
- An assessment of the "common safety culture construct" and of the balance between the three pillars;
- A chronological approach to assess the extent to which SIF prevention is taken into account at the different stages of the business relationship.

Part Four

The transformation

1

Build a SIF prevention system

1.1 An assessment of the current situation with a focus on SIF prevention

It is necessary to perform an assessment of the current situation where SIF prevention is concerned. There are always certain initiatives and ways of doing and thinking that are worth drawing on. The assessment of the current situation can be based on the eight areas of investigation that emerged from the discussion group's work, drawing on the SIFP Model.

Essential

The frame of reference for SIF prevention

- **The identification of SHSP scenarios:** shared methods and visions;
- **The state of the P.R.M. defence system and its barriers:** defined, practical measures;
- **The detection and monitoring of SHSP and HIPO incidents:** reporting and handling;
- **The detection and monitoring of disruptive elements and fixes:** inclusion, analyses and fixes;
- **Local management:** monitoring SHSP, P.R.M. defence system, precursors, disruptive elements, discussions, conducting reviews and practising operational experience feedback (including cause analysis), decision-making and implementation;
- **Overall management and the common prerequisites:** existence and monitoring of common methods, generic elements (SHSP scenarios, P.R.M. defence system, SIF precursors, disruptive elements) and general measures (leadership, just culture, social dialogue, CC/ECC cooperation, Golden Rules, etc.);
- **The common safety culture construct:** status of the three pillars in internal relations and in the CC/ECC relationship;
- **The important steps in the stages of the business relationship:** the inclusion of SIF prevention in the different stages of the business relationship: internal and external outsourcing.

The relations between internal entities (engineering, works, maintenance, operations) are included in the assessment via the frame of reference.

1.2 The elements of the P.R.M. defence system: design and implementation

1.2.1 Identification of SHSP scenarios

Key point

Severity, severity potential

Defining and agreeing on what is meant by "severity":

- for people (employees or third parties): disability, injuries, death, etc.;
- for the facilities, the environment and material objects: the extent of the damage.

Use of **criteria for severity potential** (energy, operational experience feedback, simulations, etc.).

Key point

Generic SHSP

Establish a list of generic SHSP scenarios for routine activities. These SHSP can relate to three areas:

- industrial, manufacturing or service processes;
- situations relating to the work environment;
- simultaneous operations (SIMOPS) with fellow workers, contractors, third parties and external facilities.

Key point

Shifting from generic SHSP to the reality

Shifting from generic SHSP to the reality means taking into account the real conditions in which work and operations are performed in an environment such as it really is. A "360° view" is then important to accurately analyse this reality, particularly the combinations of the three areas involving risks, according to the actual working conditions.

1.2.2 Design of the barriers in the P.R.M. system

A vision of the three pillars and of the kinetics of implementation is necessary

FIG. 26: *Barrier design: integrating the "3 pillar" vision to establish the barriers*

A barrier is a set of measures generally based on three pillars: technical aspects, safety management system (SMS), and human and organisational factors (HOF). Even for the purely technical measures (such as an automatic system for blocking access to a zone if a risk exists) workers need to be trained on what to do if the system fails, or a rule needs to be in place for handling the failure and keeping people safe.

Design the barrier implementation and control process

It is important, too, to take into account the steps involved in implementing a barrier (kinetics), as they are described in Figure 12. It is also through this construction that the control of their implementation can be built.

The barriers, their complementarity

The prevention, recovery and mitigation barriers cannot be designed separately.

Key point

Recovery: a defence to develop further

Recovery is important, as it is often ignored or underestimated. Preparing minds for a recovery in the event of a SIF precursor is essential. It is on this basis that it is possible to build targeted shared vigilance. The ability to use STOP cards in these situations is major. It is also possible to imagine new, more technical forms of recovery such as proving dead, a warning system or a reminder to stay vigilant, by taking advantage of the possibilities new technology provides and by cross-checking.

Key point

Mitigation: go beyond the standard measures

Further brainstorming needs to take place regarding mitigation barriers, in order to move beyond standard PPE, alarm systems and emergency assistance.

Detecting and monitoring precursors or SHSP

Situations with a high SIF potential (SHSP or Potentially SIF) are the "diamonds" of the Bird pyramid. It is essential to detect and address them. To design a SIF prevention system, precise preparation is therefore needed in this area.

Key point

SHSP (or SIF precursors): rare and essential data

Here are a few pointers for improving their detection and reporting.

- Give positive recognition when SHSP (SIF precursors) are reported, even if an error was made;
- Help detection by listing real, possible SHSP and launching some kind of "search operation" to encourage people to look out for them;
- Match them to "possible recovery measures" and encourage the reporting of actual recoveries;
- Create and disseminate benchmarks focused on serious accidents and their SHSP (SIF precursors);
- Analyse SHSP and HIPO incidents jointly with the stakeholders concerned;
- Show the importance attached to these analyses and their results;
- Ensure SHSP are reported and shared.

Disruptive elements: create awareness of their impact on defences

Often, everyone knows what the disruptive elements are, but they are neither analysed nor addressed. Real attention to their impact is lacking, particularly due to the combination of several of them when accidents occur. Often, chronic problems are not dealt with because they are beyond the control of the workers most affected.

Key point

The frequent chronic disruptive elements endured

- Make the sharp-end workers aware of the importance of the disruptive elements;
- Regularly review these disruptive elements and their impact on the P.R.M. system;
- Use the five areas (external, gap between planning and execution, direct from individuals, industrial processes, management and organisation) and analyse the causes;
- Put in place a system to warn workers and to shut down operations in the event of an abnormal combination or of an occasional disruptive element.

Description of the P.R.M. defence system

It is important to describe the P.R.M. defence system associated with each generic SHSP that must be known and shared by many workers.

Example of a description of a "damage to high-risk networks" defence system, useful for all who work on roads

Example

- **SHSP scenario:** presence of unidentified high-risk underground networks (mainly gas, electricity and steam networks)
- **SHSP (SIF precursor):** working near these networks without the appropriate tools and knowledge
- **Event: damage to infrastructure (network)**
  - Severity: with or without a short-circuit (or discharge of steam or gas), with or without release of gas into the atmosphere
- **Defences (examples)**
  - **Prevention:** precise and up-to-date plans and information, identification
  - **Recovery:** use of soft or "manual" techniques near networks if there is the slightest doubt
  - **Mitigation:** wearing of PPE (against flash), fast response system (network operator's telephone number, fire brigade, reinforced gas procedure), fast excavation evacuation procedure, measures in place for safety perimeters
- **Potential disruptive elements and fixes (examples)**
  - **Erroneous response to the declaration of intent to carry out works in proximity of services/utilities (disorganised handling of these declarations and various people involved):** revise organisation and procedures
  - **Deficient mapping and accuracy classes, lack (deficiency) of surveys from the contracting authority/engineering firm:** action plan, mapping, information and geographical positioning of structures
  - **Use of inappropriate tools, workers insufficiently trained:** improve training and tools.

1.3 Design and implement the two levels of management and the common prerequisites

1.3.1 Local management

Implementing local management that is appropriate for SIF prevention is essential to success.

The control system: managing SHSP and P.R.M.

Key point

Establish the scope of control: activities of an entity, worksites, operations, etc.;

- Take stock of the information that is useful to management: SHSP scenarios, barriers, SHSP (SIF precursors), disruptive elements, fixes, HIPO incidents, accidents, etc.;
- Build systems for reporting issues and dealing with the information, as well as for reviews and operational experience feedback;
- Identify or create "moments necessary to the management process": periodic or site meetings, wrap-up meeting when work is completed, etc.;
- Keep an up-to-date record of the actions decided and their results;
- Report useful information and unresolved problems to overall management.

1.3.2 Overall management

To implement SIF prevention, an overall management level must be created and organised to ensure the system works as it should.

Overall management: ensuring the SIFP Model works as it should

Key point

- Ensure the method is well understood and properly implemented;
- Conduct audits and verifications of key elements such as reviews being held and operational experience feedback being gathered at the local levels;
- Keep the information regarding results reporting, performance, important factors relating to SIF Prevention (ecosystem) and the corresponding indicators (to be determined) up to date;
- Address any issues unresolved by the local level and involving the overall level.

1.3.3 Common prerequisites

Common prerequisites are general measures which apply to all who practise SIF prevention. They are necessary to its smooth implementation and must be designed, established and disseminated according to the assessment of the organisation's current situation.

Key point

The common prerequisites: a solid foundation for success

- Take stock of the current safety culture, if possible by performing an assessment (diagnosis) or by examining the attributes of safety (see Fig. 19)
- Identify the measures aimed at encouraging a shared awareness of the most significant risks, such as managerial involvement, the misuse of the incident rate, explaining the content of safety cases;
- Identify the general measures to promote in order to encourage the reporting of precursors and disruptive elements: just culture, information flow;
- Encourage client company/contractor company cooperation with a new contract policy which includes SIF prevention.
- Implement Golden Rules or Life-saving Rules, to give the culture concrete form and ensure its evolution;
- Focus social dialogue on the most important accidents;
- Lastly, ensure that management leadership focuses on this theme as a priority, so that every worker will know it is the priority of the entire chain of command.

1.4 Summary: how to build a SIF prevention system

Essential

- Gain an accurate picture of the current situation by assessing it according to the eight themes in the frame of reference;
- Implement a system for identifying SHSP scenarios: severity potential, 360° view, etc.;
- Design the P.R.M. defence system and its three levels of barriers (nature and kinetics);
- Build a system for detecting and reporting SHSP and for analysing their causes;
- Make everyone aware of the importance of disruptive elements and their combinations, and address these;
- Organise a local management level to address SHSP, HIPO incidents and disruptive elements, as well as monitor the defence system;
- Establish an overall management level which ensures that SIF prevention is properly implemented and monitors the main reports and indicators;
- Determine what general measures (common prerequisites) are necessary, implement the measures most appropriate for the situation.

2

The stages of the transformation towards a new SIF prevention system

2.1 A necessary evolution of the safety culture

The realisation that major change is needed in order to more specifically address SIF prevention brings a shift away from the usual methods.

Challenging certain dogmas deeply embedded in people's minds is a must:

- ▷ "If we reduce near misses, irrespective of their severity potential, we will reduce the number of serious injuries and fatalities";
- ▷ "There are two distinct categories when it comes to accidents:
  - occupational accidents, to which the general prevention methods apply;
  - industrial accidents, which involve the industrial processes. These require specific methods for risk analysis and for identifying major accident scenarios in order to determine ad hoc prevention measures."

Through its work, the discussion group demonstrated that:

- ▷ the decline in occupational incidents or accidents, which results in a reduction of the TRIR, was not correlated with a similar decline in serious injuries and fatalities;
- ▷ the strict separation between industrial accidents and occupational accidents does not reflect reality. Particularly where serious and major accidents are concerned, the two categories can frequently have causes in common and these require very similar analysis and prevention methods based on accident scenarios.

To challenge the general paradigm on these matters, significant action is required on the safety culture. In a way, this is a change that requires organisations to follow the stages involved in shifting from a safety culture to an integrated culture, as these have been laid out by ICSI.

FIG. 27: *The stages of the transformation towards an integrated safety culture (ICSI)*

2.2 The stages of the culture change needed for SIF prevention

The implementation of SIF prevention requires a shift of the safety culture towards the adoption by all – at all levels of the organisation and even outside of it where the contractor companies are concerned – of a specific approach to SIF prevention. This change depends on the safety culture of the entity in question, but will follow the different stages of the evolution of the safety culture towards an integration of the principles of SIF prevention and of the ways and means to achieve it.

The safety culture evolution process must be combined with the design and, following this, the implementation of a SIFP system, as set out previously *(see Transformation § 1.4)*.

2.2.1 Diagnosis

The diagnosis, or assessment, is based on a frame of reference covering eight themes directly linked to the construction of the SIFP system *(see Transformation §1.1)*. The other part of the diagnosis focuses on the state of the safety culture. The strengths and weaknesses of the culture can be determined from this assessment of the current situation, which includes the client company/contractor company relationship. Based on these, the transformation towards SIF prevention can begin.

It is important, for example, to gain an accurate picture of elements such as: a shared awareness of the most significant risks, a culture of transparency when it comes to reporting precursors and disruptive elements, management leadership, and the level of worker commitment and engagement.

A precise assessment of the management system must be carried out, because it needs to be adapted to SIF prevention *(see Transformation § 2.3)*.

2.2.2 Vision

It is important for the organisation's top management to set themselves a goal for the companywide implementation of SIF prevention, based on the results of the diagnosis. First, they need to be convinced of the need to change to attain ambitious SIF reduction objectives. Therefore, the person heading the project needs to convince top management of the need for a new approach to prevention which sometimes goes against what the top managers advocated previously.

The evolution strategy will depend on the state of the organisation's safety culture. It will be different if there is a strong shop-floor culture or if, on the other hand, a bureaucratic culture pervades. For example, if the chain of command needs to be convinced of the new direction, the strategy will include ensuring that they have a firm grasp of it. The time it will take to implement depends on this and the size of the organisation.

The coalition, i.e. the people mobilised to champion the project, will have to take into account the risk of some people not being convinced of the usefulness of the change. They will need to work closely with opinion leaders, employee representatives and those in charge of contractors.

2.2.3 Programme

The design of this programme will have to incorporate the mainstays of the SIFP system: P.R.M. defence systems based on situations with a high SIF potential (SHSP), the local and overall management levels, and the prerequisites.

But this implementation of a specific organisation structure will have to be coupled with actions focused on communication, embedding, awareness-raising, support, and on preparing necessary general actions (prerequisites) such as: the just culture, client company/contractor company cooperation and its inclusion in contract policy, the preparation of successful social dialogue on these topics. The strategy must thus be built by taking into account these needs and the opinions of the stakeholders concerned, and by ensuring that the various necessary sub-projects are implemented in chronological order.

Special attention must be paid to the existing safety management system and its evolution. As a general rule, the organisation should draw as much as possible on what works well in its existing system. Indeed, the transformation is not about wiping out everything that was there before and starting from a clean slate; rather, it about adapting it in a pragmatic manner, particularly since the safety-related actions will need to last.

2.2.4 The way forward

This is about the deployment of actions. It is worth ensuring that all workers come to realise the importance of the change, through initiatives that will help them to grasp the new concepts developed in the new system. Using real-life situations and case studies involving hazardous situations, near misses or accidents, worker discussions about the new concepts must be encouraged.

The discussion group organised some workshops to be run at the sharp end, at the facilities of companies that volunteered. The workshops were focused on assimilation at the sharp end and the most suitable method to have emerged from these various tests is outlined below *(see Transformation § 2.4)*. Successes will be apparent quite rapidly in concrete actions such as safety visits and briefings/debriefings, which will show all concerned the importance given to SIF prevention and how that is effectively reflected in everyday managerial actions *(see Transformation § 2.5)*.

2.2.5 Anchoring

The new practices need to be sustained for the long term. One difficulty is that even though they are intolerable, serious and fatal accidents are fortunately often rare. That is why the change needs be reflected in managerial actions such as those mentioned previously: safety visits and briefings/debriefings, meetings, shared vigilance, etc. Highlighting SHSP and how much the organisation values them being reported and addressed also helps to anchor the new practices long term.

2.3 The safety management system

The existing safety management system often covers a large portion of the necessary functions. Consequently, change for the sake of change is not useful. There are, however, certain elements for which it is important to clarify the specific adjustments needed for SIF prevention.

The following table elaborated by the discussion group lists these elements. The two levels of management (local and overall) are one of the important elements of the SMS.

The safety management system adjustments required

Element	Evolution
EHS policy: commitments, general principles	Make clear the importance of SIF prevention (SIFP).
External regulations, internal rules, general requirements	Insist on the major requirements, golden rules, shared vigilance, just culture. Prerequisites.
Knowledge and evaluation of risks	SHSP scenarios, the criteria for high SIF potential, and methods.
Areas of focus, programmes, action plan and improvement	The programme for transformation towards SIF prevention (SIFP)
Professional skills	New managerial skills and common concepts everyone needs to be familiar with (e.g.: workshops)
Organisation	Roles and responsibilities. Local and overall management with delegations.
Management, monitoring and operational experience feedback	Analysis of SHSP, incidents, accidents and indicators.
Verifications, audits and reviews	The specific points with a high SIF potential to monitor and check (e.g.: methods, management, etc.)
Information reporting and handling	Info to collect: results, ways and means, ecosystem.

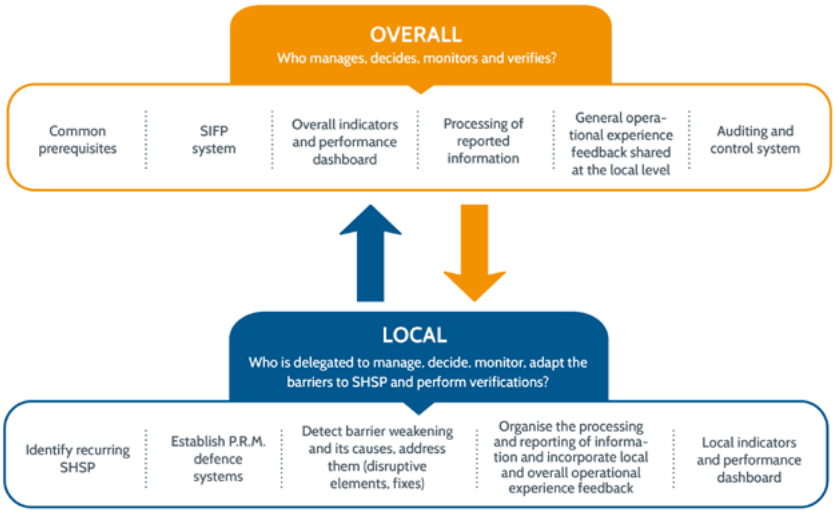

FIG. 28: *SMS: the set-up of the two levels of management – local and global*
Plan, consult, adapt, train and set up the two levels of management

The safety management system will focus more particularly on the design and implementation of the two levels of management. Particular care must be taken with this.

2.4 Assimilation by the sharp end teams

Assimilation: a concrete approach in tune with the concerns of sharp-end workers

Practice

The discussion group considered how the sharp end teams would assimilate the new concepts and ideas developed in the SIFP system. To this end, several workshops were held at the sharp end to test the approach. These revealed that the best method is to start with a situation those present have experienced. This can be a hazardous situation, a near miss or an accident. The facilitator explains the concepts and the participants help to fill in the SIFP Model diagram with elements that correspond to the situation they experienced. It can be useful to ritualise this type of approach in team meetings.

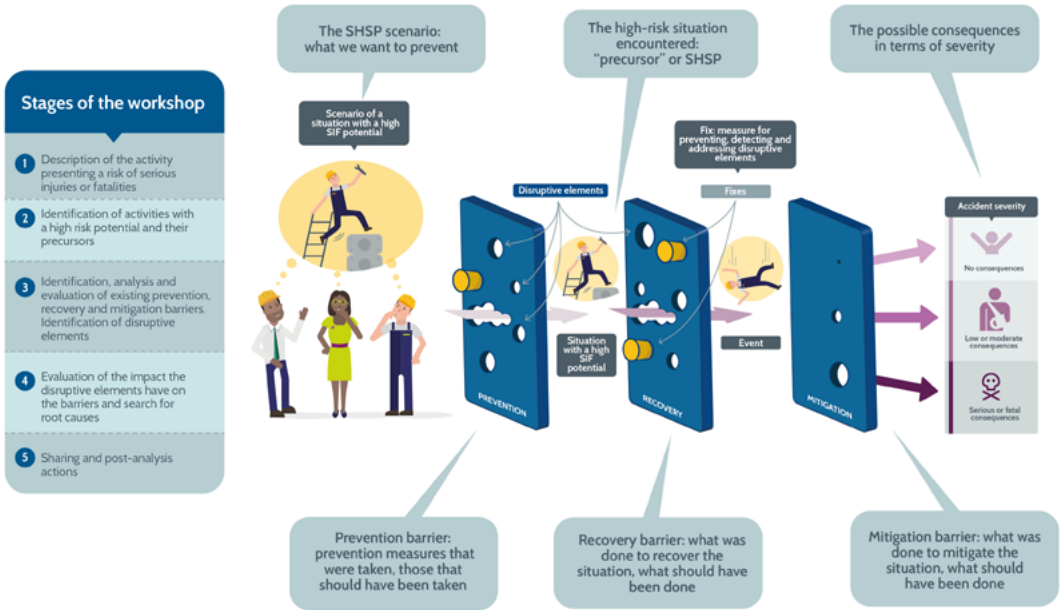

FIG. 29: *Workshop method for assimilating the SIFP Model and related concepts*

2.5 Two actions that are emblematic of the transformation towards a new approach to SIF prevention

2.5.1 The safety visit by management

The safety visit by management is an important act. It is an opportunity to listen to the people at the sharp end and an essential means of communication for managers. They can use this time to express what they see as crucial where safety is concerned. During these visits, it is essential to talk to the workers about situations with SIF potential and the measures taken to prevent, recover and mitigate (P.R.M.) them. The prerequisite for this type of visit by management is a willingness to listen and ask questions.

The figure below presents the important elements identified by the discussion group.

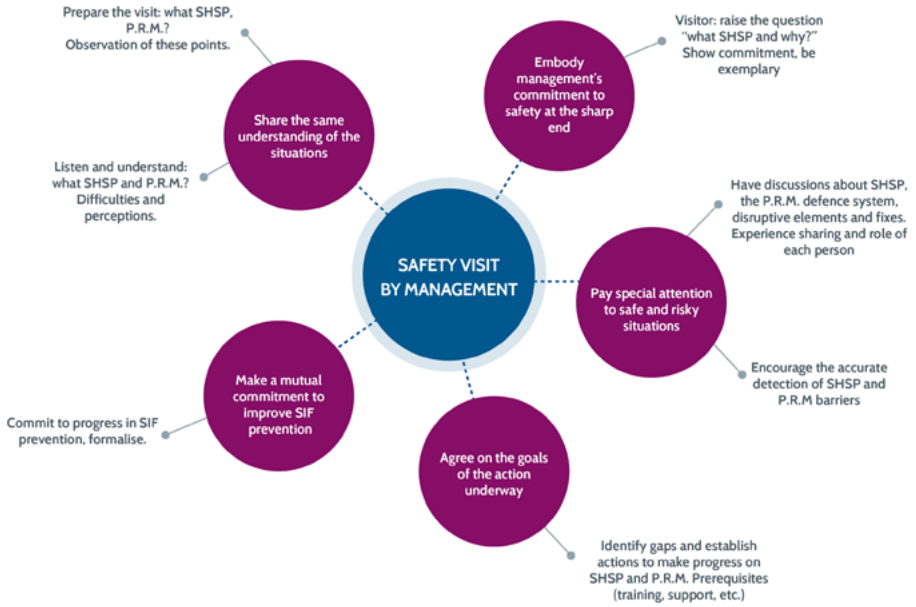

FIG. 30: *Taking SIFP into account during safety visits by management*

The safety visit by management is an essential part of prevention. These visits are an opportunity for employees to get the true measure of management's commitment to safety and for managers to discuss and exchange views with them about prevention-related matters. The main elements of SIF prevention can thus be broached: SHSP scenarios, the P.R.M. measures taken on the worksite in question or in response to frequently encountered problems such as disruptive elements and the ways to avoid them (fixes), and whether these measures are understood or not. This valuable time spent at the sharp end should reinforce the shared conviction that it is possible to considerably reduce serious accidents, and thus renew the workers' commitment and their support of SIF prevention. Figure 30 outlines the five main objectives of safety visits by management and the important points of SIF prevention that should be covered.

2.5.2 Pre-operations briefing

This act by local management makes the SIF prevention concepts tangible.

First-hand experience

First-hand experience of a recovery barrier briefing

During the briefing for an operation involving work in a confined space, the team leader realised that they were lacking a trained worker.

The SHSP: risk of suffocation in a confined space with a high percentage of toxic gases.

The prevention barrier entails constantly measuring the atmosphere and having a competent, trained person present at all times outside the cavity.

The precursor would have been carrying out the work without the trained second person being present.

The disruptive element was the gap between the planning and the execution: absence of a trained person.

The recovery barrier: the briefing, which made it possible to stop the operation.

2.6 Summary: for the transformation towards effective and integrated SIF prevention

The transformation towards effective SIFP requires a structured approach to the change which involves most of the actors of the company and stakeholders concerned. The system must be designed and built, and at the same time the conditions for success must be put in place, as there are essential to the changes. All echelons of management must be completely committed in order to achieve success.

Conclusion

The work carried out by the "Serious Accident Prevention" discussion group revealed a new vision of the way to tackle this issue.

Given that the classic methods have been unable to decrease the number of serious and fatal accidents, the traditional model, which consists in reducing risky situations irrespective of the severity of their potential consequences, was called into question.

The SIFP Model that was built based on the discussion group's discussions and deliberations summarises a new manner of approaching this prevention.

It is important to take into account the client company/contractor company relationship. Indeed, regardless of the business activities being conducted, there are relationships of this type with all kinds of service providers, whether these are internal or external to companies.

The shift from a classic SIF prevention method to that presented in the SIFP Model requires a safety culture transformation. The review of the situations encountered shows that the areas concerned by this prevention are often highly compartmentalised within organisations, with industrial accident prevention on one side and occupational accidents on the other. Moreover, the idea that by reducing the number of incidents, irrespective of their nature, we could reduce the number of serious injuries and fatalities is very widespread and ingrained in people's minds.

This transformation must be carried out by simultaneously building a defence system of the same type as the one presented in the SIFP Model and by taking the safety culture through the five stages of evolution towards an integrated safety culture.

By combining the discussions that took place during the group's sixteen meetings and the studies carried out within companies, on the pilot worksites and at the workshops run at the sharp end, our wish was to build a system based on both theoretical considerations and on concrete feedback from the workers on the front line at the sharp end.

We hope that the fruit of this work will help you to gradually increase the effectiveness of your SIF prevention. Reducing or eliminating serious injuries and fatalities remains everyone's goal and priority. This strong, common desire gave impetus to all who contributed to the discussion group's work, the results of which are summarised in this *Cahier*, irrespective of their role within the companies, trade unions, associations, institutes and other organisations involved.

List of abbreviations

API: American Petroleum Institute

FMECA: Failure mode, effects and criticality analysis

BST: Behavioral Science Technology, Inc.

CC: Client company

ECC: External contractor company (contractor company)

PPE: Personal protective equipment

HOF: Human and organisational factors

HOFS: Human and organisational factors of safety

GFT: General failures types

HAZOP: Hazard and operability studies

HIPO: High potential

HSE: Health, safety and environment

ICSI: Institut pour une culture de sécurité industrielle (Institute for an Industrial Safety Culture)

Ineris: Institut national de l'environnement industriel et des risques (French National Institute for Industrial Environment and Risks)

LOPC: Loss of primary containment

LOTO: Lockout/tagout

MASE: Manuel d'amélioration sécurité des entreprises (Manual for the improvement of company safety)

RCM: Risk control measure

OGP: International Association of Oil and Gas Producers

OPPBTP: Organisme professionnel de prévention du bâtiment et des travaux publics (French Organisation for the Prevention of Occupational Hazards in the Construction Industry)

SHSP: Situation with a high SIF potential

SIFP: Serious injury and fatality prevention

SPIS: Safety performance indicator system

SWA: Stop work authority

P.R.M.: Prevention, Recovery, Mitigation

HR: Human resources

RFP: Request for proposals

SIF: Serious injuries and fatalities

SIMOP: Simultaneous operation

SIMOPS: Simultaneous operations

SMS: Safety management system

STAMP: Systems-Theoretic Accident Model and Process

STPA: Systems-Theoretic Process Analysis (N. Leveson)

TRIR: Total recordable injury rate (number of recordable accidents per million hours worked)

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