INDUSTRIAL ACCIDENTS SURVEY: METHODOLOGICAL PROPOSITION

ETUDE DES ACCIDENTS INDUSTRIELS: PROPOSITION METHODOLOGIQUE

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ABSTRACT

The survey of work accidents requires a very important information flux which is possible to structure only through a methodological proceedure. This study confirms this proposal and suggests a way of survey of industrial accidents that permits the organization of information related to work accidents and the specific methods allowing the survey of this type of industrial incidences.

Keywords: technological and human factors methods of survey, causes tree.

1 INTRODUCTION

The analysis of work accidents requires a knowledge of causes that provoked them. The research of these causes is a delicate task. Indeed, after hours of witnesses interviewing, the analyst collects information often redundant and superfluous [1-4]. To overcome this difficulty, the analyst's first task consists therefore in *organizing* the obtained information in order to analyze them.

In this context, we propose a methodological proceedure permitting the *identification*, the *structuring* and the *analysis* of the accident *causes*.

This methodology is composed of three stages:

- the first stage consists in a compilation of accidents causes;
- the second stage permits to *establish the accident process* by considering the logical links and temporal tie consideration between the causes;
- the third stage proposes preventive and protection measures.

These stages are supported by *models* that permit research, the representation and the analysis of accident causes. The choice of these models is, therefore, very important. Since they not only permit to facilitate research and the structuring of the causes but also to make in evidence those that don't come to mind.

The continuation of this survey concerns the presentation of models associated to stages of the proposed methodology.

2 RESEARCH OF ACCIDENT CAUSES

The model associated to this stage consists in an arborescent representation of information, Figure 1. This arborescence is composed of three levels: main, intermediate and elementary level.

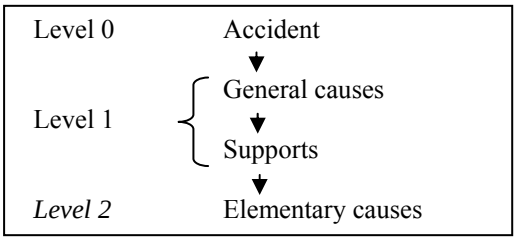


Figure 1 : Informational levels related to accidents.

2.1 Main level

The main level is the one of the accident : "an accident is everything that affects the human and/or material environment"[5], Figure 2.

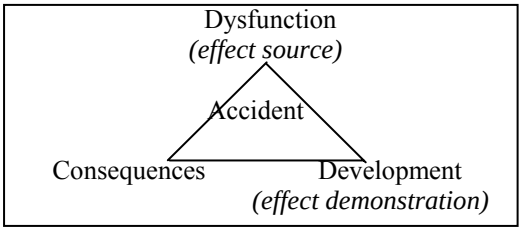


Figure 2 : Accident Model.

2.2 Intermediate levels

The intermediate level starts by the research of sources of *dysfunctions1,* since the accident is the consequence of the dysfunctions.

The first source of dysfunction is of a human origin, that is to say the causes related to man. These causes can be [6] :

- of psychological order (hostility, anxiety,…),
- of physiological order (physical, bad mood, tiredness, deafness, anxiety,…),
- of sociological order or extra professional (life style,…),

The second source of dysfunction is of a technical origin. These can be [7] :

- risks associated to raw materials, products, bad design, dimensions
- inherent risks to tools and machines.
- operating conditions: temperature, Corrosion, Wear, Fatigue, Brittle fracture, Creep, Overloading,…

The third source of the dysfunction causes is associated to the task itself such as the positions and postures : height…

The fourth dysfunction source is related to the social and work environment.

From these dysfunctions sources which constitute the general accident causes, the supports of the accident causes are determined by the combinations of the previous sources [8]. Thus, one gets 16 supports of type (X, Y), see Table 1. The support (X, Y) corresponds to the dysfunction of Y due to the cause X. It is distinct from the support (Y, X).

The appendix 2 describes the general causes supports.

		Passive support Y undergoing the action of X			
		H	M	T	E
Active support X acting on Y	H	HH	HM	HT	HE
	M	MH	MM	MT	ME
	T	TH	TM	TT	TE
	E	EH	EM	ET	EE

Table 1 : Supports of the accident causes.

H = dysfunction related to man.

M = dysfunction related to machine or used product.

T = dysfunction related to task.

E = dysfunction of the environmental origin.

1 The appendix 1 enumerates the possible dysfunctions in the enterprise system.

2.3 Elementary level

The supports of the accident causes are going to act as the basis for the elementary causes description.

The appendix 3 provides an extract of the elementary accidents causes.

3 CAUSES ACCIDENTS MODELLING

The graphical representation (or modelling) of the accidents causes permits assignement of a meaning to the dysfunctions mechanisms.

The modelling permits to reconstitute in a logical and chronological way the process of accident therefore; while putting in evidence the relations between the different causes of accidents. The model used in this survey is the facts tree [9] whose *construction* is based on :

- the sorting of the elementary causes
- the identification of the logical and temporal links between the causes.

3.1 Elementary causes sorting

The elementary causes sorting permits to distinguish between the different types of accidents that are represented below.

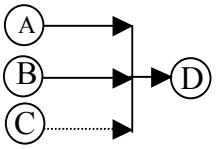
Type of causes	Graphical representation
These causes represent an unusual character in relation to workprogress	
These causes present a permanent character and take an active part to the accident happening by the mean of/or with the unusual causes contest.	
Those that present an *occasional character*.	

Table 2 : Types of accident causes.

3.2 Identification of the logical and temporal ties between causes

This stage corresponds to the organization of causes in view of the construction of the tree. The tree construction rules are provided in Table3.

Remark : in the case where one of causes would be deferred in the time in relation to the other causes that contribute in the realization of the same consequence, the take in consideration of this shift in the time takes *in dotted lines* as the famous following figure :



In this figure the occurrence of C is differed in the time in relation to occurrences of the causes A and B. But, the three are necessary and sufficient for the realization of the D consequence.

Type of link	Description	Graphical representation
Linear sequence	An antecedent, Y, has only one cause X.	X → Y
Conjonction	An antecedent, Z, has at least two distinct origins.	X, Y → Z
Disjonction	Two antecedents, Y and Z, have one only and the same origin X.	X → Y, Z

***Table 3 :* Logical links between accidents causes.**

4 ILLUSTRATION EXAMPLE

4.1 Narration of accident

This example, simple but sufficiently representative [10], corresponds to an operation of ferry stackings in cardboards containing bottles. While doing this task, a worker of small size is wounded to the foot. The height of stacking is 1.75m. The worker uses a wooden palette to gain some hight.

4.2 Research of accident causes

Let's recall that causes of accidents are human, material, organizational and environmental origin.

For this accident, the supports of causes are:

- HO = physiological maladjustment to work station,
- OH = influence of tasks on the individual features,
- OO = risks related to tasks articulation,
- OE = maladjustment of the operative modes to certain circumstances,
- EH = effect of the environmental work on the human presence.

The causes connected to the previous supports are :

- the worker is of a small size,
- the worker's tiredness,
- dimensions and the weight of pasteboards,
- the height of stacking,
- use of a palette to raise higher work plan height.

4.3 The Accident cause tree

By respecting the conventions of graphical representation of the causes and the logical and temporal ties between these causes, one gets the following tree of causes:

The study of the figure 3 might arise some remarks:

- the permanent causes (4) and (5) provoke an unusual event (3),
- the event (2) causes in the time tiredeness of the worker (the event 1),
- the event (3) is necessary but not sufficient; since walking on a palette doesn't necessarily generate an injury. Therefore, it is in conjunction with the event (1).

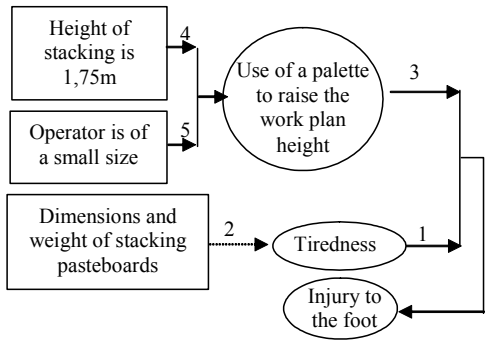


Figure 3 : Tree of causes of the accident.

5 THE TREE EXPLOITATION

The constructed tree possesses the following fundamental property : «every event, in the tree, is a necessary cause for the accident to happen».

For this reason, every cause corresponds to a *factor of accident* and therefore the measures are taken on these factors of accidents.

In the case of the previous example, the corresponding measures are given in Table 4.

The proposed measures must respect a certain number of requierements [9]: the measure life cycle (E_1), its cost (E_2), its application delay (E_3), its conformity to the reglementation in application (E_4), the production requirements (E_5),…

M_1 =	The se of a well adapted floor,
M_2 =	To review the size of the pasteboards →to decrease the number of bottles by pasteboard,
M_3 =	To predict some regular pauses to avoid the tiredness,
M_4 =	Limitation of the stacking height,
M_5 =	Selection of workers,
M_6 =	Automation of the stacking device.

Table 4 : List of the prevention measures.

The respect of all of these requirements is not possible. A compromise, often necessary, consist in a discussion of the measures proposed. This latter is based on the requirements weighting, Table 5.

The weighting scale that we propose for the previous requirement is:

0 the E_i requirement is not respected,

1 the E_i requirement is more or less respected,

2 the E_i requirement is well respected

In the ideal case, where all requirements are respected well, one gets a total of 10 points. The weighting of every measure corresponds therefore to the following ratio: Sum of weights allocated to every requirement (from 0 to 2) over 10.

Measures	**Requirements weighting**	Measures weighting
M_1	$E_1 \rightarrow 1$; $E_2 \rightarrow 2$; $E_3 \rightarrow 2$; $E_4 \rightarrow 2$; $E_5 \rightarrow 1$	8/10
M_2	$E_1 \rightarrow 1$; $E_2 \rightarrow 0$; $E_3 \rightarrow 2$; $E_4 \rightarrow 2$; $E_5 \rightarrow 0$	5/10
M_3	$E_1 \rightarrow 1$; $E_2 \rightarrow 1$; $E_3 \rightarrow 2$; $E_4 \rightarrow 2$; $E_5 \rightarrow 1$	7/10
M_4	$E_1 \rightarrow 1$; $E_2 \rightarrow 0$; $E_3 \rightarrow 0$; $E_4 \rightarrow 2$; $E_5 \rightarrow 1$	4/10
M_5	$E_1 \rightarrow 2$; $E_2 \rightarrow 1$; $E_3 \rightarrow 0$; $E_4 \rightarrow 2$; $E_5 \rightarrow 2$	7/10
M_6	$E_1 \rightarrow 2$; $E_2 \rightarrow 0$; $E_3 \rightarrow 0$; $E_4 \rightarrow 2$; $E_5 \rightarrow 2$	6/10

Table 5 : Prevention measures weighting

After discussion, one gets the measures classification proposed by the efficiency order:

M_1

M_3 & M_5

M_6

M_2 & M_4

The classification of measures proposed show that the actions of prevention must be, in a first time, on the adequacy of the palette to the carried out work. This measure has the advantage of assuring the continuity of the stacking operation while foreseeing in short and medium-term other more efficient preventive measures.

The forecasting of these measures is *progressive*: it is first about reviewing the dimension as well as the weight of pasteboards stacked and the selection of workers capable of doing this kind of operations. Finally, the of the stacking device automation, in the case where the stacking frequency would justify it, permits to reinforce the security of this kind of operation.

CONCLUSIONS

The proposed methodological approach permits to treat the problems often met by the industrial accidents analysts.

Applied on a simple and issued example from literature, our approach permits :

- a better diagnosis of information on the accident studied,
- the integration of the time factor in the causes tree of,
- the introduction of a the weiting tool of the prevention measures in view of their selection.

Also, it's worth noting that the stages of our methodology are not "*freeze"*. Indeed, it is quite possible to begin from the first or the second level, or even from the third level if the case studied is simple or if it was already the object of previous studies.

Also, we need to mention that to every level of this methodology, one can consider the involvement and the collaboration of other specialist: programmers, sociologists, …) in the elementary causes refinement or in the research of prevention measures.

Finally, the proposed methodology permits the research of the accident causes and not of the responsibilities.

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Appendix 1. Sources of dysfunctions at the different levels of the enterprise [9].

Levels of tea enterprise	Sources of dysfunction
Entreprise	Administrative adjustment lack to production units Insufficient coordination of activities Unrest or insufficiency of the communication
Service	Bad distribution of tasks Insufficiency of affectation rules Functional instability, social instability,
Team	Bad circulation of information Lack of cohesion of the team
Station	Material (signaling, orders, signal coupling orders, state of the material) Organization of work station (time factor, requirements of excessive work, conflicts of criteria, difference of elementary task statute) Conditions of environment (the noise and effects of mask, lighting deficiencies) Feature of the worker (perceptive system properties, motor, sensori - motor and cognitive, representations of situation of work and attitudes, unsettled state transient)

Appendix 2. General causes supports [8].

Support	Description
HH	Effect of the human presence on hiself or on another.
HM	Effect of a human presence on the material.
HO	Psychological or physiological maladjustment to work stations.
HE	Influence of the human presence on the work environment
MH	Dimensions and protection of work stations
MM	Incompatibility of technical elements or products between them
MO	Maladjustment of the material to a task
ME	Maladjustment of the material or the product to an environment.
OH	Influence of tasks on the individual features.
OM	Abnormal use of the material.
OO	Risk related to the tasks articulation.
OE	Maladjustment of the operative modes to certain circumstances.
EH	Effect of the work environment on the human presence.
EM	Effect of an environment on a material or a product.
EO	Influence of the environment conditions or the social environment on the task.
EE	Reciprocal effect of an environment on another.

Appendix 3. Extract of the accidents elementary causes[8].

Support	Description
HH	Staff rotation, communication problems,….
HM	Deterioration of a product or a material due to a human presence, maladjustment of the individual to the work station,...
HO	Maladjustment to a task, level of formation, physical or mental inaptitude,...
HE	Overcrowding of a work station, foreign presence,…
MH	Bad conception or planning of work stations, problems of interface between the machine and the man, discomfort of the individual protective devices, ...
MM	Materials of different technologies, incompatibilities of chemicals products between them, …
MO	Tinkering, inconvenience brought to work by individual or collective protections,…
ME	Nuisances or pollution produced by the working of machines,…
OH	Rhythm of work, tiredness, problems of health,…
OM	Use out specification of the material,…
OO	Bad division of work, conflicts between sequences of tasks achievement, …
OE	Works in hot places, presence of a thermal motor in an exploding atmosphere,…
EH	Noise, vibrations, radio - protection, dusts, lighting, toxicity, risk of pressure,…
EM	Problems of conditioning and storage,…
EO	Thermal discomfort, insufficient lighting, dismissal of a group,…
EE	Spark + exploding steams → explosion,…