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### **Work Accidents and Professional Diseases**

The major accident is defined as “any event occurred, like an emission of dangerous materials or agents, which emerges from uncontrolled evolutions along the exploitation of any objective that leads to the immediate or delayed occurrence of serious dangers with impact over human health or over the environment, inside or outside the objective in which are involved one or more than one dangerous materials”. The dangerous phenomenon is a potential source of harms. In the ambit of industrial risks of accidental origins, this expression more frequently refers to physical phenomena like conflagrations, explosions, toxic gases dispersion, etc. Any accident scenario relates itself to the potential effects at the level of environmental “targets”. In the case of major accidents, we can distinguish the following categories of “targets”: human (employees of the objective, working or resident people in the nearby of the emplacement); the installation or equipments that may stay at the origin of the accidents (dangerous equipments); certain all-important equipments to ensure the safety level of the installation (critical security equipments: control rooms, civil fire brigade headquarters, etc); goods and structures situated in the installation’ environment (ground water, rivers, soil, flora, fauna).

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#### **1. Breakdown, driftage, unwanted event**

The breakdown represents the ceasing of an entity to accomplish its function. The breakdown type represents the effect through which a breakdown is noticed, in the case of an entity.

In practice, making the difference between the breakdown and the breakdown type is sometimes difficult. With this purpose, let’s take into consideration the case of a pump whose main function is to ensure a certain debit. The breakdown of the pump refers to the absence of the necessary debit at the pump’s output. This

breakdown becomes obvious if the pump would not start. The effect "the lathe would not start" is a possible breakdown type for this equipment.

The parameter can be defined as a measurable physical variable or an operation that needs to be accomplished. For example, the most frequent parameters in thermal-hydraulic systems are temperature, pressure, debit, concentration, density, viscosity degree and time.

The driftage of a parameter is the driftage of a parameter related to a reference value. This state of reference depends, mainly, on the condition of the considered system (normal functioning, turn off, turn on). The driftage generally represents the outcome of a breakdown.

## **2. Events and dangerous situations**

In the ISO / CEI guide, the dangerous situation is defined as the situation in which the people, the goods in the environment are being exposed to one or more dangerous phenomena.

This definition is less applicable in case of major accidents occurred in industrial objectives, when the exposure of the targets is semi-automatic since the moment of the occurrence of a dangerous phenomenon, taking into consideration, for example, the exposure of the personnel and of the equipment from the analyzed objective. Consequently, the expression "situation of danger" is being used, meaning the situation that, if it is not controlled, may lead to the exposure of the targets to one or more dangerous phenomena.

The central unwanted event represents the direct cause of a loss of tightness or physical integrity. (E.g. pressure rising, external mechanical aggressions, corrosion).

The undesirable effect can be any type of driftage or breakdown that denotes a deflection from the normal exploiting conditions (E. g. a fireplace in the nearby of a dangerous equipment).

## **3. The elements involved in the working process and their interaction**

The accidents of work and the professional diseases are random events, and their occurrence can only be probably estimated. By definition, they are compulsory in relation of causality with the elements of the working process. The analysis of the intimate mechanism to produce them should therefore comprise all the elements in this process.

Regardless of the nature of the activity, in any working process there are four elements involved that interact and influence themselves mutually, in order to accomplish an unique aim:

- The Executor (E)
- The Working Task (WT)
- The Means of Production (MP)
- The Working Environment (WE)

In other words, the elements involved in the working process represent a system – working system – made up of four components: EXECUTOR – WORKING TASK – MEANS OF PRODUCTION – WORKING ENVIRONMENT.

THE EXECUTOR is the person directly involved in the execution of the working task.

THE WORKING TASK represents all the actions the executor must perform in order to achieve the working system goal. It is circumscribed by all the executor's behavioral steps in relation to the means of production and the working environment.

The executor relates himself to the task through skills, professional knowledge, customs, etc. The human agent can be found in the system even indirectly, as a conception and decision factor behind all other constituents. Hereby, the working task, as well as the means of production or a part of the working environment (physical environment) are conceived or driven by man. Under the aspect of the genesis of accidents of work, as it might be seen afterwards, the only thing that matters is the executor's deficiencies, the other deficiencies (of the decision and conception factors) finding themselves at the level of production means, environment and working task.

THE MEANS OF PRODUCTION represent the sum of the working means (buildings, installations, machines, tools, means of transport, etc.) and working goals (raw materials, intermediary products etc.) employed in the material goods producing process.

THE ENVIRONMENT represents the climate in which the executor accomplishes his activity.

The working environment comprises on one side the physical environment (the working room the group relationships, illuminating conditions, microclimate, noise, vibrations, radiations, air purity etc.) and on the other side the social environment (the group relationships, the horizontal and vertical relations etc.)

THE WORKING PROCESS represents the sequence in time and space of the executor's conjugated activities and the means of production in the working system. For a working process to take place, it is necessary that all four elements previously described coexist in time and space and to be correlated between them. The bonds that generate are shown in the Figure 1.

In the working system, the executor and the material elements came into relation functionally through the working task.

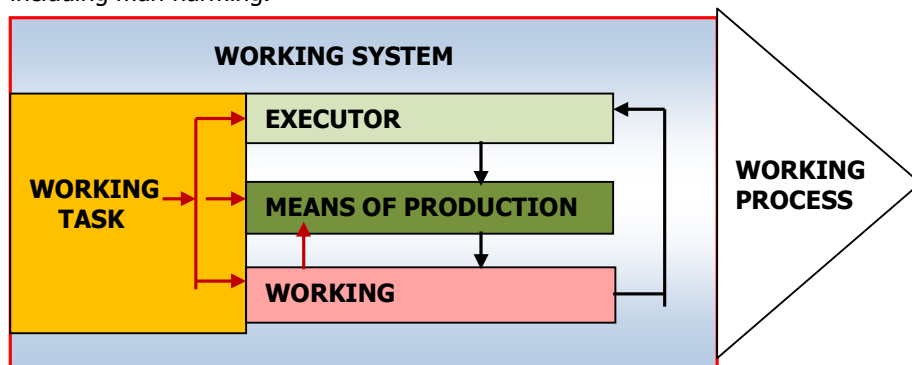
In relation to the executor, the task and the working environment have a direct action upon it, while the means of production have only an indirect action, through the task. Consequently, the generic existence of all four elements is not sufficient for establishing a working environment and passing off a working process. They should coexist in time and space and to interact, not randomly, but with the reason of a common goal. The way the interactions take place is essential for achieving the aimed goal. The first feature establishes the working process as being the space in which the accidents of work and industrial diseases take place, and the

second characteristic allows the understanding of the pop up process of the two types of events.

From the point of view of labour protection, the working process displays two main characteristics: the presence of the man having the quality of executor and the capacity of the elements involved in his achievement to build a system – the working system.

If the accident of work and occupational disease phenomena is treated as compulsory effect circumscribed to a working process, to reach the causes that brought it forth, we must establish and analyze what happens inside this circumscription room, respectively inside the working system.

If the elements involved in achieving the working process run and interact properly, they will achieve the goal for which the system was created, respectively the one to produce and not to destroy itself. Any type of deficiencies of one or more elements, meaning a deflection in the system's pre-established activity leads to the rising of entropy, which is the indication of its self destructive tendency, including man harming.



**Figure 1.** The elements involved in accomplishing the working process and the relationship between them

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The accidents of work and occupational diseases are therefore disfunctions of the working system, generated by the derangements, qualities and inherent characteristics of its integrating elements.

The possibility of such deflections to occur, but also to correct them through proper measures, lies in the nature of the working system itself, defined through the following characteristics:

a) The system is opened through its human component and semi-opened through its technical component (means of production and physical environment);

b) The system is dynamic, changing its conditions under the influence of time. Three condition profiles become obvious, significantly distinctive according to the possibility of producing deviations from the normal conditions:

- condition profile with optimizing tendency;
- optimal condition profile;
- involutive condition profile.

c. The system is complete, meaning that its way of acting is not reducible to the components' characteristics and conditions took separately or as a simple (arithmetical) sum.

d. The system is self-adjustable, meaning it possesses the capacity to use the information about the action's previous regulatory effects to correct the eventual deviations or errors or to improve future actions.

e. The work system is determinant through its condition and relatively random through its actual functioning way.

The system's deviations do not always necessary lead to harming or altering human health. To produce such an effect it is required to establish a causal chain, whose last link is the connection between the victim and the material agent that harms it. The chain is made up of factors (qualities, conditions, processes, phenomena, behaviors) belonging to the elements of the working system, that represent potential causes for producing accidents and / or occupational diseases, respectively risk factors for producing accidents and / or occupational diseases (abbreviated as risk factors). Usually, risk factors represent deviations from the normal conditions or functioning way of the elements of the work system.

#### **4. Risk factors in the work system**

What has been previously shown results in the fact that the manifestation room of the risk factors is the work process itself. To emphasize them it is needed systematic analysis of the accidents causing features and possible deviations of the system.

Risk factors pertaining to the executor

The executor's eventual deviations from the ideal line that he should follow to achieve the working task always represents an error, at the level of one or more main links of the working activity, as it follows:

- Reception, manufacturing and interpretation errors;
- Decision errors;

- Execution errors;
- Self-regulating errors.

The executor's error embodies an inadequate behavior from the labour security point of view, under the effect of a wrong action or omission. Analyzing the possibilities of error of the executor related to the other elements of the work system results in the list of risk factors belonging to the executor.

At the level of the working task may come up two categories of potential accidental causes or occupational diseases.

- Improper content or structure of the working task in relation to the aim of the work system or with the requirements needed by the risk situations (operations, rules, mistaken procedures, lack of some operations, incorrect working methods);

- Underdimensioning / overdimensioning of the requirements imposed on the executor, respectively not corresponding to his possibilities.

Analyzing the means of production in relation to the executor, we obtain the sequence of risk factors.

Depending on the nature of their action, the risk factors pertaining to the means of production can act in the following manner:

- Mechanical risk factors, whose action lies in the sudden, uncontrolled and not indicated release of the kinetic energy incorporated in the means of production or in parts of these;

- Thermal risk factors, in the situation of whom the potential danger is given by the action, of the thermal energy incorporated in the means of production at the contact with the executor or by being handled by him;

- Electrical risk factors, for which the danger lies in the possibility of the direct or indirect contact between the executor and the electric energy used by the means of production;

- Chemical risk factors, whose action is determined by the harmful chemical or potentially accidental properties of the chemical substances handled during process;

- Biological risk factors, with biological action, harmful or potentially accidental, depending on the characteristics of the macro and microorganisms used during the working process.

The risk factors belonging to the working environment

The physical environment might display deviations in the form of surpassing the level or the functional intensity of the specific parameters (microclimate, noise, vibrations, chemical gases, radiations, lightning, etc.), or characteristics that represent improper working conditions (physical over solicitation).

The social environment is described through risk factors of psychological nature, whose result lies in the over solicitation of the executor.

The systematical study of these characteristics, deviations in relation to their negative action, generating actions or occupational diseases over the executor, leads to the generic list of risk factors.

## **5. Classification of the risk factors and ways of acting in the working system**

By making it real from possible, the action of the risk factors becomes a real danger for the executor, which may lead either to the violent harming of the organism, by injuring its anatomical integrity, causing the voidance of one or more of its physiological functions, either to diseases of the organism. In case of the occurrence of this kind of events, it means that risk factors became (real) causes of accidents or occupational diseases.

It is not though possible a very strict delimitation of those two categories. In certain conditions, the specific difference is only given by the level and the lasting of exposure of human organism, so that an illness factor may become an accidental factor and vice versa. For example, until a certain noise level becomes a harmful factor, causing affections of the auditory organ; its sudden emergence at a very high intensity leads to work accidents, under the aspect of traumatizing the auditory organ or by covering an important technological signal, simultaneously provoking an accidental reaction of the executor. Reciprocally, an accidental factor as the cracking of a pipe might determine also an occupational disease depending on the transported agent emitted in the working environment through the rift.

As for the delimitation in accidents generating factors and occupational diseases, it is based on another difference that concerns the manifestation form of the risk factors in the working system: variations or conditions.

The variations are the movements that deflect from the normal course, respectively the sudden disfunctions involved in achieving the working process. By definition, these are characteristic to work accidents. Variations belong to all the working system's elements; objects roll, a machine starts without being controlled or would not answer to the turn off command, the executor stumbles and falls, liquid jets, balance, back strokes etc.

The conditions are attributes, properties, human deficiencies, deficiencies of the means of production having a relative permanent character, the reason why they are most likely to be found in the occupational diseases' etymology. Not only the static elements previously mentioned are conditions; by its relative permanent character, also the functional circuit of a cog represents a condition that may lead, though, to a working accident and not to an occupational disease.

The occurrence of working accidents implies the interaction of variations with conditions. Without at least a variation that assures the sudden, unpredictable character, the interaction of the conditions cannot lead to accidents.

In certain cases, conditions may turn into variations; by the sudden raise of intensity, conditions may become accidents producing variations. Ultimately, though, this transmutation is a variation itself. Consequently, a higher level of lightning of the working place normally represents a sicken factor because it affects the visual analyzer (through accentuated exhaustion). The sudden growth of the same type of lightning might cause an accident though, by directly blinding the executor.

In what the genesis of some by others is concerned, no option is excluded: for a state (condition) to produce a variation in some conditions and for a variation to produce a condition. For example, the presence of explosive gases permanently resulted from the technological process in the working place's atmosphere represents a condition; their accumulation over a certain level (the limit of explosiveness) determines the trigger of a variation – the explosion. Vice versa, the cracking of a pipe represents a variation; if through the pipe circulates a harmful agent that spreads and is maintained continuously in the atmosphere, it means that the variation produced a condition.

Another classification criterion useful for preventing possibilities analysis, but also for the genesis of producing working accidents and occupational diseases is the nature of the risk factor, respectively:

- Objective risk factors that do not depend on the human component and that are specific only to means of production and (physical) working space;
- Subjective risk factors, depending on the human component, specific to the executor and to the working task.
- Depending on their real or potential contribution to produce an accident or an occupational disease, the risk factors can be:
  - Primary, by whose suppression the possibility of harming the human organism is completely eliminated;
  - Secondary, that favour the effects of the main factors' action, and whose suppression does not represent a guarantee to avoid producing accidents or diseases.

### **6. The action of the risk factors over the human organism**

As it has been shown before, the factors' action can lead either to the violent harming of the organism, by injuring its anatomical integrity, causing the cancellation or the diminution of one or more of its physiological functions, either to affecting the organism. In the first case an accident of work occurs, and in the second case an occupational disease occurs.

Nowadays, depending on the nature of the factors that provokes them, five types of injures become evident: mechanical, thermal, electrical, chemical, of irradiation or combined.

The occupational diseases' board is in fact unlimited. Because of practical reasons though, the legislation from various countries conventionally limits the number of occupational considered diseases. Depending on the nature of the risk factor that has generated them, the occupational diseases can be:

- Intoxications caused by inhalation, ingestion, or by the contact of the epidermis with toxic substances.
- Pneumoconiosis, caused by the inhalation of non-toxic mineral powders;
- Irradiation diseases;
- Diseases caused by the exposure to high or low temperatures;
- Diseases caused by exposure to noise or vibrations;



- Diseases caused by exposure to high or low air pressure;
- Occupational allergies;
- Occupational dermatosis;
- Occupational cancer;
- Infectious or parasitical diseases;
- Diseases caused by over-solicitation;
- Other diseases.

### **7. The relation risk factor – causes**

According to the determinist conception, in the objective reality, there is nothing without having been provoked by a cause: any cause represents the effect of another cause and itself provokes other effects. The surrounding reality, being in a continuous change, appears as a multitude of linkages of the cause – effect type. The accidents of work and the occupational diseases represent final moments – the effects – of unwanted causal linkages.

In the moment the damaging of the organism is produced (accident, disease), the potential causes – risk factors change into (real) effective causes of those events. Therefore, the causes of the working accidents and occupational diseases (abbreviated causes) represent factors (characteristics, conditions, processes, phenomena, behaviors) that have provoked the accident or the occupational disease.

As for their content, the notions of risk factors and causes represent the same thing, the differences appearing only in relation with the moment the damage took place is analyzed. Usually, before the accident we speak of risk factors and after the accident, when the possibility turned into fact, about causes.

The same way as the risk factors, the causes of the accidents of work and occupational diseases can be classified according to the above shown criteria.

### **8. The dynamic of the accidental and occupational diseases phenomena**

The occurrence of a work accident involves the action of at least two causes, a subjective and an objective one, because only this way the impact between the victim and the material agent that affects its organism can occur.

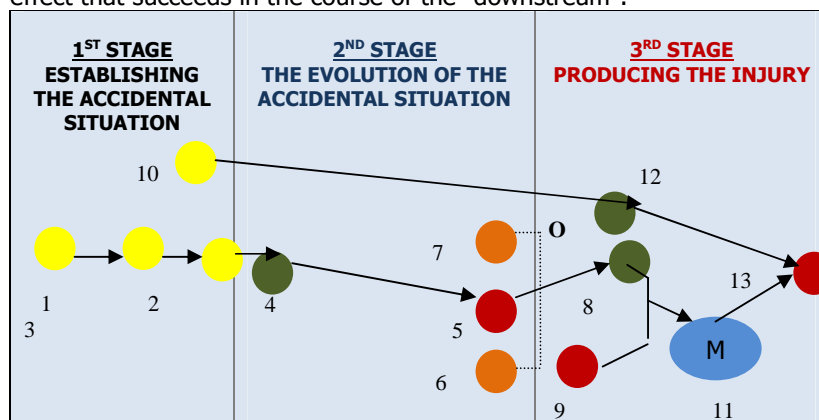
Maintaining the preceding stage of the injury, it can be affirmed that it is required that the interaction between an objective risk factor and an objective one, belonging to the executor, like his simple presence, take place.

Usually, though, these “minimal” causes represent the last link of serious causal chains. Knowing the continuity of causes - effects that lead to accident is imperious because it offers intervention and stopping possibilities on the path in similar situations, as well as establishing the prevention measures.

Consequently, the accidents’ dynamic during work processes might be described as a continuity of causes – effects, recklessly if it is analyzed as a potential scenario or after the event has been produced, which is in progress

during working process. At one end of the chain the initial cause can be found, situated the farthest in time from the moment of the injury, but only after the work system was produced and activated. At the other end we may find the final cause, situated the nearest from the producing of the injury. In the dynamic of accident occurrence, the causes connect between themselves and combine from "upstream" towards "downstream", distinguishing, from this point of view, two ways of connection:

- The linear connection of causes, so that the "upstream" cause represents the effect of the "downstream" cause, and, afterwards, itself becomes the cause of the effect that succeeds in the course of the "downstream".



**Figure 2.** Theoretical model of the dynamic of working accidents occurrence

The combination of two or more causes that generate a certain effect, that creates a cause situated "upstream" from these and which, by itself, can determine another effect or it may represent the final cause.

In any situation, to produce the accident, the establishment of the linear connections chains of causes is required; the annihilation of a single sequence of these is sufficient to avoid harming (domino principle). According to what has been specified, we can distinguish another two types of causes: primary and secondary or favouring. The primary causes are those whose annihilation breaks the causal chain, those who represent the compulsory links for producing the accident.

The secondary causes are those who, combining with the primary causes, lead to the production of another primary cause. The presence of the favouring causes is not compulsory for a certain effect to appear; they only contribute to the evolution of the primary cause, in other words, producing the effect.

In the dynamic of the accidents' production, we may notice three possible stages (Figure 2.):

a) 1<sup>ST</sup> Stage: establishing the accidental situation, which begins with the nearest cause from the moment of the injury and which is characterized by the following:

- It is apparently not differentiated from the normal situation, so that the danger cannot be noticed if it is especially traced;
- A noticeable dangerous situation appears, which is initialized by the human constituent;
- Usually, it is possible to interfere in order to prevent the accident by the executor, as well as by the decision factors;
- b) 2<sup>nd</sup> Stage: the evolution of the accidental situation, that consists of the enchainment and the combination of many causes, generating the final cause; the phase's characteristics are:
  - The enchainment and the combination of several causes take place, in a short interval;
  - Because of time crisis, the executor's preventive actions might worsen;
 There is though the possibility, very limited in relation to the previous stage, to intervene in order to prevent the injury;
- c) 3<sup>rd</sup> Stage: Producing the injury, stage in which the final cause finally acts:
  - It is the definitive cause of the accident;
  - The contact of the man with the elements of the means of production or of the physical environment takes place, that leads to the injury through combining the two chains of linear linkages;
  - It is produced in a very short period of time, so that the only possibilities to react are the self-defensive reflexive reactions of the executor.

In relation to their place in the accidental dynamic, we can distinguish three types of causes: initial, intermediate and final, and depending on the final effect: direct causes, respectively, the final cause whose effect is the injury itself, and indirect causes, that produce another cause, intermediate or final. The initial cause and the intermediate causes are always indirect. The more "upstream" they are from the moment of the accident, the larger and safer possibilities to prevent the injury they offer.

1, 2, 3, 4, 5, 8, 9, 10, 11, 12, 13 – primary causes; 6, 7 – secondary causes; 1, 2, 3, 10 – initial causes; 4, 9 and 12 – intermediate causes; 11 – the final, direct cause; 13 – injury (the accident).

From the enchainment of the initial causes 1 – 3 we obtain the intermediate cause 4. The effect of cause 4, made by cause 5, combined with the favouring causes 6 and 7, generates the intermediate cause 8. This, conjugated with the primary cause 9, provokes the final cause 11. The initial cause 10 determines cause 12 (the presence of man in the same place with cause 11), which allows combining the two linear enchainments and producing the injury 13.

The global pattern of the accident of work's dynamic

Practice has shown that there are situations in which identifying all the causes inside of a working system, according to the previously shown pattern, is not enough. Irrespectively of the forces majeure, it has been certified that most of times, the disfunctions of the elements involved in achieving the working process emerged from outside the working system and before its establishment and

starting (for example, flaws interfered in the projection or enforcement of the working project).

### **9. Conclusions**

Based on the mentioned differences, the deviations with whom the elements involved in achieving a work process might get into a work system will be designated as a causal substratum of the accidents of work.

Concordant to the high risk categories belonging to each element we might also designate the possible deficiencies of the causal substratum nature.

In the case of the executor, his mistake, who materializes in a riskful conduct, might be the consequence of an individual working capacity. On his turn, this is characterized by a number of variables, whether semi static (as for the skills, experience), or instantaneous (like fatigue), that might make up permanent or temporary incongruences with the requirements enforced by a certain work process, and that came up before the individual takes part in achieving it.

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