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Perception of an emergency situation by operators in an oil refinery

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ABSTRACT : This paper describes the first stage of a study in which the general objective is to analyse the operators' behaviour during an emergency situation in an oil refinery. The aim of this stage was to characterize an emergency situation from operators' perceptions of it. The method consisted in interviewing a sample of operators and in a presentation-validation with all the operators concerned by the study. The results show that two characteristics were expressed more than others : the identification of risks in situations at a given time and the necessity to act quickly. The nature of these risks or the probable negative consequences to avoid are significant disturbances of the process, the unit shutdown, the environment, equipment and human body damages. At the end, based on operators' expression, we define the main characteristics of an emergency situation.

1. INTRODUCTION

This paper describes the first stage of a study in which the general objective is to analyse the operators' behaviour during an emergency situation in an oil refinery.

An "emergency situation" is a general term, used for certain circumstances in personal and professional life. In the latter, one naturally thinks of men and women who work in fields that specifically treat emergency situations : firemen (their activity was analysed by Samurçay & Rogalski (1993)), and emergency room physicians. In risk industries, Emergency Intervention Plans and emergency procedures exist. This allows to take into account the variety and the complexity of the configurations of an emergency situation. Notably due to their very diverse forms, it seems that the expression of an "emergency situation" is subjective. Consequently, what is an emergency situation ? And, in particular, what is it for the refinery operators ?

Fixari & Pallez (1992) define emergency : "given an individual or collective actor, who must carry out a task by a given deadline, emergency is a judgement made by this actor in a given instant, on the importance of this deadline, and on the insufficiency of time remaining to meet it". This definition emphasizes the subjectivity of the word "emergency" through the word "judgement", as the authors point out. As for Flin, Slaven & Stewart (1996), they define the task of managers on high-risk sites (specifically, offshore oil platforms) in an emergency as being complex and characterized by the time pressure, uncertainty and danger.

Can these definitions of "emergency" be transferred to that of "emergency situation" ? ; do they characterize the emergency situations experienced by the refinery operators ? In other words, can these definitions be adapted to the particular context of a refinery and of the activities of these operators ? Also, in light of these questions, we have chosen first, to understand what is an emergency situation for these operators, based on their statements. The objective is to characterize an emergency situation from these statements.

This paper explains first the methodology used to characterize an emergency situation from the operators' point of view, the hazards in a refinery, the operators' training for emergency situation. Next, the analysis of the interviews with some operators will be presented before concluding about the main characteristics of an emergency situation from operators' point of view.

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2. METHODOLOGY

2.1. Methodology of Gathering Data

We conducted half-directive individual interviews with voluntary operators (their answers being anonymous). We questioned them about what is an emergency situation for them, and to describe one of their personal experiences concerning this case. Moreover, these interviews contained other questions concerning the operators' training, their normal work conditions, their work tools ... within the framework of our general knowledge about the specificities of their work.

In order to obtain a representative sample of the operators, we took into account several variables :

- the number of operators interviewed to the total number (21 out of 85, in other words a quarter of the total work force) ;
- the operators functions, which include outside operators, boardmen and chief operator ;
- their seniority in the company.

The interviews were tape recorded and later transcribed.

After this first stage was completed, we presented to the operators from every shift the opinions expressed in the interviews concerning the question, "what is an emergency situation", and added our general formulation on this subject. This stage consisted in three objectives : to expose our work to all of the operators, to globally evaluate the representativity of the interviews and to validate our characterization of an emergency situation, which was reconstructed from these interviews. In order to achieve these last two goals, we asked the operators to inform us when they did not agree with what their colleagues had expressed in the interviews or with what we have formulated. This last stage allowed the operators to discuss their different perceptions about their work situations and comment on the viewpoints expressed in the individual interviews.

2.2. Methodology of the Data Analysis

This method is broken down into three stages.

The first one consists in reworking the interviews in order to make them easier to analyse by distinguishing each situation and characteristic expressed (not described here).

The second stage was to gather the situations and characteristics that were expressed by more than one operator.

Finally, the last stage consisted in picking out the most frequently occurring elements expressed in order to characterize an emergency situation.

3. THE HAZARDS IN AN OIL REFINERY

Potential hazards of various nature are present in a refinery. They can affect environment, and/or equipment and/or humans.

The nature of these hazards consists in : explosions, leakages of hydrocarbons (liquid or gas), leakages of toxic products (hydrogen sulphide, benzene among others), and fires. The leakage of hydrocarbons can ignite in the presence of a hot source depending on their pressure and temperature : this is a flash fire or an explosion. The environmental risks correspond to air, water and soil pollution.

These hazards can damage the human body in the following ways :

- explosion pressure or debris impact ;
- intoxication, burns and suffocation through inhaling toxic products ;
- different degrees of body burns ;
- contact with toxic or corrosive products.

Facing these different risks, the refinery has developped a Safety Management System whose main objective is the operations integrity. So as to reach this objective, the system bases on taking actions of different kinds : organizational, technical, training, risks analysis and corrective and preventive measures. Thus, the chief of the operators has the responsability to decide the unit shutdown, if he considers it necessary. Technically, many automatic safety systems exist and their functioning is regularly tested. Moreover, several committees periodically meet so as to re-examine and validate the risks assessments already done (notably in incident reports) and the necessary corrective or preventive actions. Finally, the operators' training and the existence of procedures constitute a fundamental measure of the risks management. The next paragraph globally describes the operators' training.

4. THE OPERATORS' TRAINING FOR EMERGENCY SITUATIONS

All of the operators work in the same control room, from which five units are monitored.

Each shift of operators consists in outside operators, boardmen and one chief operator.

Everyone starts in the position of outside operator. Later, it is possible for these workers to be promoted to boardmen and eventually to chief operator. Once the operators are certified to hold several positions, they "rotate". Thus, a certified boardman holds more or less on a regular basis the outside operator position for which he is certified.

The operators are trained for every position in the same way : they are paired with a senior operator and they learn written procedures. As for the boardmen, they normally receive extra training on a simulator. Learning the procedures is the method used to prepare the operators for certain unusual situations during their training, such as special operations (the shutdown and start up of the units) and emergency situations. More details on operators training are given in Cadet, Pineau & Pioche (1997).

Three types of procedures exist : routine operation procedures, special operation and "emergency procedures" (for the last one, the refinery uses the English word). The emergency procedures are written as a series of actions, in which some of them give explanations.

Continued training for emergency situations consists in creating new procedures in teams and in analysing the existing procedures with an expert.

5. INTERVIEW ANALYSIS : CHARACTERIZATION OF AN EMERGENCY SITUATION

5.1 The emergency situations expressed by the operators : a risk scale

We asked the operators two questions "what is an emergency situation for you ?"and "describe one of your personal experiences of emergency situations". Regarding the first question, most of the operators spontaneously responded by giving examples of emergency situations instead of trying to give a straight definition. Nevertheless, certain operators also cited general characteristics: "a work situation that could involve a significant risk - this is the equipment safe configuration", "a situation containing something that is a hazard for the outside operators", "when you must extract the unit from a situation, which if left alone, could lead to danger for the individuals and to significant risks for the equipment", and "a situation where you must quickly intervene to avoid the problem from getting worse, if not we end up in an 'emergency' (said in English by the operator) and so a safe position must be immediately re-established".

Every operator cited more than one emergency situation. Naturally, the length of each response depended on the prolixity of each operator.

As regards the two questions, the types of situations expressed in decreasing order of frequency (number of answers) are :

- fire (cited by 17 out of 21 operators). Nevertheless, not all of the operators who cited this case had personally experienced it;
- unplanned unit shutdown (cited 15 times);
- leakage of hydrocarbons or toxic products (cited 12 times): this includes situations that contain ignition risks. At least two operators mentioned the risk of being burned in the case of a leak.
- essential pumps for the unit's operation that are out of order, such as the pumps at the bottom of the tower and the feed pumps (9);
- power and utility failures (7);
- situations with a risk of explosion (5);
- unplanned shutdown of the compressors (5);
- situations with a risk of unit shutdown (4);
- unit emergency shutdown in which the automatic safety functions stop working (3).

In addition to these emergency situations cited by several operators, other cases were brought to us by individual operators. For example, an outside operator remembers a water hammer in a pipe and the computer screens going blank in the control room ; a chief operator recalls the rupture of a tube in a furnace....

5.1.1 First Accounts

The emergency situations described by the operators are most often the consequence of equipment failure. There was no difference between the emergency situations described by the boardmen, outside operators and chief operator.

The situations described as an emergency: " a risk of unit shutdown ", " the compressor shuts down ", "the main pumps stop working ", " power and utility failure ", " the unit shuts down ", all are connected to an unplanned unit shutdown. They either mention a

situation with great risk of a shutdown or where a shutdown actually occurred.

Due to dynamic process, it seems that if the operators consider unit shutdown as an emergency situation to be avoided, thus, a risk situation is as much an emergency as the shutdown itself. So, the first operator said "either we succeed in getting the equipment back on route and thus the emergency is over or we are really in an emergency situation implying the unit must be shutdown (because it places the individuals and equipment at risk)". Other operators spoke about, "the loss of power in the pumps at the bottom of the tower in a given unit is a great bother because at that point the entire unit can shutdown" and "when a shutdown is triggered in an unit, it's an emergency situation, but even before... if we can try to save the units, we are however there to get products".

Through these responses, two main categories of emergency situations came to light :

- situations with a risk of damaging the human body – these correspond to situations of fire, leakage or with a risk of explosion -
- situations with a risk of unit shutdown as well as those where such a shutdown could not be avoided.

In the latter case, the possible causes of a unit shutdown must be explained – a shutdown decided by the operators or an automatic emergency shutdown which depends on the unit and on the nature of the incident-. Schematically, an unit shutdown is required when a major malfunction provokes a disturbance such that, if the malfunction cannot be recovered after a certain amount of time (recovering time depends on the process) :

- the process can no longer function (e.g. unexpected loss of feed pumps due to mechanical incident);
- and/or these disturbances will deteriorate the equipment (towers, exchangers, reactors, furnaces...) (e.g. acid flowing into unequipped zones);
- and/or these disturbances could damage the human body (increase in pressure, temperature, risk of leakage...).

For the operators, depending on the causes that lead up to the unit shutdown, the latter signifies that the production is stopped, and/or the equipment is put into a safe configuration, and/or the workers are no longer at risk. Also, the emergency shutdown of the unit corresponds to a phase in which the equipment could be "shaken up". Some operators described emergency situations containing a risk of a unit shutdown where the shutdown was perceived either as a stop in production which must be avoided, or as an equipment safe configuration or as protection of the workers and the equipment.

5.1.2 Presentation to the shifts operators

During the presentations to all the shift workers, no major or massive divergence of opinions was expressed in regards to the operators descriptions. Nevertheless, some comments were made concerning certain emergency situations. For example, during an interview, an operator described one emergency situation as follows : " when a major pump collapses the other must be quickly started, because if not, it really becomes an emergency... if you let everything shut down the level can rise, so this can create problems soon after without going so far as causing a fire ". Another operator said, "when the feed pumps collapse, this is an emergency situation because it implies the unit shutdown". Moreover, a boardman explained, " the level rising in a tower, the pump functions well in order to evacuate the product, but the level continues to rise... so, we don't know the actual level and so we must react ; in an extreme case, we can produce non-conform products or bypass a part of the unit ". Some of the operators expressed during the presentation that they consider these situations urgent to deal with in order to avoid further process disturbances or unit shutdown, but they do not consider these as emergency situations. This difference in perception among the operators did not seem to be linked to experience or seniority since some senior operators described the above cases as emergency situations.

5.1.3 Levels of emergency situations

The common point found in all of the described situations and some general definitions given by a couple of operators was : the identification of risk by the operator - but depending on the situations, these risks can be of various nature. The nature of these risks corresponds to the idea of the different levels that make up an emergency situation. This notion of levels was expressed by two of the operators during their personal interviews and by some others during the presentation meeting by way of summarising the diversity of the emergency situations described.

We can draw from the operators' responses the nature of these risks or the levels of the emergency situation. These are :

- risks of significant unit disturbances, of non-conform production ;
- risks of production shutdown and equipment damage;
- risks of human body damage.

Furthermore, due to dynamic process, the risks can evolve, and their nature also. Thus, it can be said that this evolution of risks constitutes a risk in itself for the operators.

These levels encompass the diversity of the perceptions of an emergency situation, and notably including those considered as urgent situations for some and emergency situations for some others.

Through our initial questions, in addition to these emergency situations described essentially from a technical point of view, the operators spontaneously reported other characteristics of their activity in emergency situation.

5.2 Characteristics of an emergency situation from the point of view of the operators' activity

Through the operators' descriptions, other dimensions of an emergency situation can be highlighted. These dimensions, formulated with variable frequency, turn mostly to work activity and its conditions of realisation in emergency situations.

- An emergency situation is a work situation where actions must be taken quickly (cited by 14 operators)

The rapidity of the action is a fundamental characteristic expressed by numerous operators. The rapidity of the action is necessary so as to recover the situation and to avoid it from getting worse. For example, an operator said, " the faster you intervene, the better you avoid the situation from getting worse ". The rapidity of the action is thus intrinsically linked to the evolution of the situation and its risks.

- An emergency situation is a rare or new work situation (cited by 10 operators)

The senior operators expressed the rarity nowadays of an emergency situation occurring by comparing their higher frequency just about a decade ago. The newer operators talked about the rarity and the newness of emergency situations occurring as on the one hand a positive fact and on the other a problem of training to cope with this kind of situation. Effectively, the operators must be able to put into motion knowledge and skills that they have not yet used or have only used on rare occasions. For example, a boardman reported one of the first emergency situations he had to face in which a senior boardman reassured about the way the process was reacting to sollicitation.

- An emergency situation is one in which team work is important (cited by 9 operators)

Collective work was mentioned several times but from different perspectives.

- Need of re-enforcement for the operations on the units. Two unit operators talked about the extra number of hands necessary according to the workload to be done in a short amount of time.
- Emergency assistance. A boardman explained that as an outside operator, " the first thing is to not be all alone; if you are alone, you can always call for help! ".
- Expressing and sharing feelings. One of the outside operators said that it is important to talk about incidents with each other: " team work is very important in these kinds of cases ; we need to speak freely amongst ourselves... that's what we do, and that's how it works. The major incidents that we have had are talked over in the cafeteria".
- Experienced operators help the novices. Three boardmen (two novices and one senior) explained that the senior boardmen help the newer ones by sharing their skills to cope with their first emergency situations. An outside operator reported that a more experienced operator helped him to cope with an emergency situation with his " technical tricks ".
- Obtain different representations of the situation. An experienced boardman said that it's important to have a colleague behind you : "someone who is behind you does not see the same things that you do, he can very well see things that you can't ".

Rognin (1996) did an in-depth analysis on the safest forms and functions of collective work. In particular, Rognin highlighted regulation activity and collective monitoring, elements that are described by the operators in their own words.

- An emergency situation is often an uncertain one (cited by 3 operators)

Uncertainty is based on different signs according to the situation : decision making about which action to take, the causes for the malfunctioning, and/or their consequences, information exactitude, and the real state of the process.... Three outside operators expressed this notion of uncertainty. One of them spoke about the computer screen going blank: " the

problem is that you don't know what's going on ; we ask ourselves what's really going on here ?". Other operators explained, " you must send the products in another direction, sometimes we still don't know what happened ", " when you know why you shutdown the unit, it's not a major problem, but when it gets out of control and you don't know why... ! ". This uncertainty, expressed above concerning the causes for the malfunctioning make operators feel losing the control of the situation and upset them.

- Fear of not adequately acting in an emergency situation (2)

During an emergency situation, if the operators act poorly or too late, the situation can worsen. As this is a rare or completely new work situation, a wrong action is possible. Concerning this subject, an operator explained, " you think that maybe you can't detect the problem, and you wonder if you can cope " ; and a boardman recalls his first incident at the console a couple of days after he started, " we were scared to do anything ; we knew what needed to be done, but we had never done it ". Thus, a couple of operators expressed their concerns about not acting adequately in an emergency situation, or as one operator said, " you better not mess this up ". This concern of acting poorly (that is to say, to make a mistake) is also shared by pilots, as indicated by Amalberti (1996).

- Critical emergency situations where the risks are in conflict

In certain situations, the outside operator must evaluate the risks for himself in relation to the other risks of the situation.

The operators mentioned the case of a leak of a flammable product : the outside operator, fairly close to the source of the leak risks bodily damage in the goal of reducing the possible consequential damage of this leak on the equipment, on the process and eventually on the individuals. This is a difficult situation to deal with, and it largely depends on the fairness of the evaluation made by the operators on the risks taken by them to recuperate the situation. This was expressed by two experienced operators, " if an outside operator judges that he can do it, he does it ; if not, he calls '18' (unique phone number for firebrigades in France) or " after, it depends on the individual, he either dares to go or doesn't, but in any case, you need to calculate the danger ".

- Particular assistance from the procedures in an emergency situation

As mentioned in part 4, the emergency procedures are written as a series of actions to help the operators during these kinds of situations. But, operators and their hierarchy explained that the procedures cannot be used during the emergency situation or only after the first actions have been taken. Thus, in this last case, they principally serve as a verification tool in the case that an action is eventually forgotten. As a result, we can say that the emergency procedures are more often used as training tools than as guidelines of what to do in a real emergency situation. If we base our analysis on the classification of " problems linked to the use of procedures " proposed by Veyrac, Cellier & Bertrand (1997), this rare utilisation of emergency procedures can be put under the category of " material usability " : this utilisation is difficult due to the significant time constraints. Nevertheless, this particular utilisation is not expressed as a problem for the operators and their superiors, because the operators explained that they remember the learned procedure corresponding to a case to be dealt with during an emergency situation.

At the end of this synthesis of the emergency situation characteristics, we propose to characterize the emergency situation from the most frequently mentioned points by the interviewed operators.

5.3 Characterization of an emergency situation

This concerns a dynamic situation where the operator identifies the risks (meaning, the probable negative consequences), which are evolving and various in nature. Here, the operator tries to at least avoid the transformation of these risks into real negative consequences, or at best to eliminate them by acting quickly.

The negative consequences to avoid are :

- the significant disturbances of the process, the no-conform production,
- the stop of the production (signifies the unit shutdown), equipment damage
- human body damage (this includes death).

These emergency situations are rare, treated collectively and can present uncertainty.

6. CONCLUSION

Through this study, we have simply attempted to characterize an emergency situation from the operators perceptions of it. We have not analysed all the diversity of the operators' perceptions, or the differences in perception among certain operators.

Nevertheless, this study has highlighted the following points :

- emergency situations do not only contain risks of human body damage. It also includes situations with risks of deteriorating the equipment and those with significant disturbances which could lead to a unit shutdown.
- the emergency situation begins once the operator identifies the potential / the risk that can turn into unwanted consequences, and not just when these consequences become reality. Here we find the activity of anticipation of each operator, which is well known in ergonomics.
- the operators spoke in terms of the " rapidity of the action " and not in terms of a " reaction made in an appropriate time or in a given amount of time ", as formulated by Fixari & Pallez (1992) in their definition of " emergency ". Thus, up against evolving risks, the operators do not seem to take the risk of waiting to act in order to analyse the situation more deeply.
- certain operators felt the situation to become an emergency one earlier than others who preferred to call this an urgent situation, meaning that they simply make reference to the rapidity of the action.

As for the methodology used, it revealed the benefits of general validation meetings, which allowed to distinguish the differences between the operators' perceptions that were non-identifiable during the synthesis of the individual interviews. As a result, the method could be improved by gathering less data during the individual interviews, which constitute the starting point of this study for the analyst and the basic work tool for organizing meetings with all the shift operators. Thus, the meetings would no longer correspond simply to a validation stage, but represent the principal stages of data gathering according to a method that needs to be reworked. For example, during these meetings, we can create a table of the characteristics of an emergency situation with the operators.

Finally, it seems that our characterization of an emergency situation does not significantly differ from other definitions of " emergency ". It relies on the operators' expressions and takes into account their work context. It seems that an emergency situation for an individual contains three main notions :

- perceive in a given time interval as being relatively short,
- identify the necessity to make a decision or to act,
- want to avoid the consequences of not making a decision or not acting.

The variability of the emergency situations depends on the form of action, and/or of the time interval available, and/or on the nature of the unwanted consequences. In particular, a significant variation of the nature of the emergency situations depends on the knowledge or the imprecision of one or several of these three elements for the individual.

REFERENCES

Amalberti R. 1996. La conduite de systèmes à risques. PUF, collection Le Travail Humain.

Cadet B., Pineau J.P. & L. Pioche 1997. Perception par les opérateurs des situations d'urgence en raffinerie. *in Workshop on Human Performance in Chemical Process Safety*. Munich, 24-27 June 1997.

Flin R., Slaven G. & K. Stewart 1996. Emergency decision making in the offshore oil and gas industry. *Human Factors*, 38, 2, 266-277.

Fixari, D., & F. Pallez 1992. Comment traiter l'urgence. *Annales des mine,s* Juin 1992.

Rognin L. 1996. Coopération humaine et sûreté de fonctionnement des systèmes complexes. Thèse de Doctorat d'Ergonomie. Université de Toulouse le Mirail.

Samurçay R. & J. Rogalski 1993. Cooperative work and decision making in emergency management. *Le Travail Humain*, 56, 1, 53-77.

Veyrac H., Cellier J.M & A. Bertrand. 1997. Modèle de l'opérateur et modèle du prescripteur : le cas des consignes de résolution de situations incidentelles pour les conducteurs de train. *Le Travail Humain*, 60, 4, 387-407.