

# Safety illusion and error trap in a collectively-operated machine accident

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**Abstract.** Workplace accidents involving machines are relevant for their magnitude and their impacts on worker health. Despite consolidated critical statements, explanation centered on errors of operators remains predominant with industry professionals, hampering preventive measures and the improvement of production-system reliability. Several initiatives were adopted by enforcement agencies in partnership with universities to stimulate production and diffusion of analysis methodologies with a systemic approach. Starting from one accident case that occurred with a worker who operated a brake-clutch type mechanical press, the article explores cognitive aspects and the existence of traps in the operation of this machine. It deals with a large-sized press that, despite being endowed with a light curtain in areas of access to the pressing zone, did not meet legal requirements. The safety devices gave rise to an illusion of safety, permitting activation of the machine when a worker was still found within the operational zone. Preventive interventions must stimulate the tailoring of systems to the characteristics of workers, minimizing the creation of traps and encouraging safety policies and practices that replace judgments of behaviors that participate in accidents by analyses of reasons that lead workers to act in that manner.

Keywords: Accident investigation, accident prevention, error trap

## 1. Introduction

In Brazil, accidents with machines tend to be explained in a manner that attributes blame to the victim or emphasize technical aspects of the system. As a counterpoint to this practice already denounced as inhibiting prevention, in Brazil, the Ministry of Labor and Employment (MTE) organized a project entitled Sirena, which aimed to stimulate the prevention of workplace accidents (WA) based on in-depth analyses of these occurrences. The project included efforts for the qualification of workplace auditors, development of instructional materials and of publication that combated the comprehension of an accident as a phenomenon centered on the person [1]. This old

view must be replaced by another that visualizes these events as socio-technical phenomena represented by a bow-tie [2] that includes a description of normal work, as well as analyses of barriers and of changes. The cited concepts must guide the process from the collection to the interpretation of the data.

In the same period, one of the collaborators in this project contributed with the development of the Model of Analysis and Prevention of Accidents – MAPA [3] adding some steps to the proposal adopted by the MTE, especially the notion of conceptual enlargement of analysis understood as an approach to the behaviors and aspects of the activity in question with the support of concepts from ergonomics, psy-

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chology (cognitive or labor), social sciences and others already used with success in the analyses of accidents in complex socio-technical systems.

This study is part of a review of an MTE preliminary analysis of an accident in a brake-clutch press that resulted in the amputation of a worker's arm. One of the operators activated the command to lower the hammer while a colleague was still present in the interior of the machine and despite the failure of the barriers that should impede the closing of the operational zone the behavior of this worker was emphasized as the principal cause of the event. The re-study explores potentialities of MAPA in occurrences in a situation where the data presented (feedback) to the operators can stimulate errors of diagnosis and actions that contribute to the occurrence of the outcome. This type of situation has received different denominations in the literature and in this study will be referred to generically as an error trap [4].

## 2. Method

The study was based on a copy of a preliminary report elaborated by a labor auditor with the support of concepts indicated in the Sirena project and includes solicitation of complementary clarifications when authors considered it necessary. The analysis was reviewed with an emphasis on the notion of conceptual enlargement proposed in MAPA with support for the comprehension of behaviors of those involved in the accident.

The new description presents the normal work of operating the machine emphasizing the variabilities present in the accident situation, as well as adjustments that they provoke and their implications for safety in the real work. The technical system is described with the aim of identifying faults or failures of barriers and exploring their origins. The accident is described with the support of analysis of changes and their causes. Emphasis is given to aspects of control modes adopted by the operators, comprehension of the activity's development and the history of behaviors associated with WA.

## 3. Results

### 3.1. Aspects of the accident as viewed in the company

The description of the accident in the company emphasized the fact that in one machine operated by three workers, one of them commanded the closing of the pressing zone while one colleague was still in its interior, provoking amputation of her upper limb. Despite recognizing the non-functioning status of the barriers installed in the machine, the analysis of the accident concluded that this condition resulted from the unsafe act of the colleague that had activated the descent of the hammer.

### 3.2. Description of normal work

The accident occurred in a press equipped with 04 workstations where, habitually, 08 persons worked. The machine was programmed to be operated by 03 workers, two of whom were experienced in its frontal area and, in the posterior part, one assistant who for the first time was designated for the activity. The two experienced colleagues (01 and 02) operated in the frontal part of the press by feeding it.

The work of the assistant consisted of entering the pressing zone and covering a fabricated part with a plastic sheet. Upon placing the plastic, it should remain without folds. When necessary the worker should adjust this covering, then promptly abandoning the zone of risk. The work was considered easy to execute and not necessitating prior training.

Changes in the composition of the team responsible for operating the machine were identified as a habitual variability in the system and not recognized as an indication of a threat that required additional precautions in safety management. The inclusion of newcomers on the team was not viewed as differing from the other changes.

Contrary to the safety norms the activation of the machine was performed by only one two-hand control controlled by operator 02, from a location that hampered the visualization of assistant 03, situated behind the body of the machine in a poorly lit environment.

The description formulated by the labor auditor on the occasion of the first analysis did not clarify how, given the difficulty of visualizing the colleague that was working on the opposite side of the press, the one in charge of activating the two-handed command, knew that he could already do so in safety, as he was habituated to act.

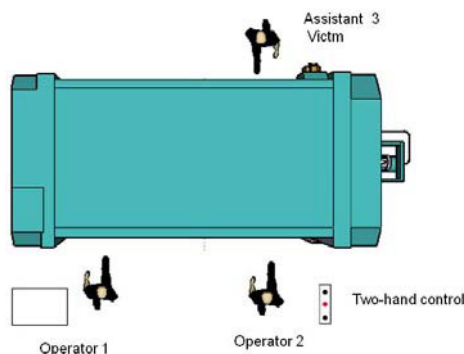


Figure 1. Disposition of workers in relation to the machine

The installation of the press safety measures was attributed to employees of a third company (by outsourcing), supposedly specialized. Apparently, none of the contractors or contracted safety professionals identified as irregular the fact that the machine was activated by only 01 bi-manual command. The machine was delivered, mistakenly received as adequate, and placed in operation.

The analysis of barriers also revealed other failures. The light curtain, installed vertically in front of each pressing zone, could be traversed, leaving the operator in a “death zone”, in other words, in an area of risk in which his presence was not detected by the sensors. The curtain and two-handed control were connected to automatic relays and not to a safety monitoring relay, which increased the chances of accidents due to failures of functioning.

The analysis of changes revealed that the two-hand control was operating with a defect. On some occasions, the activation movement was not obeyed, which required that the operator repeat his action. As the problem did not impede production and its isolated occurrence was not indicated as a threat to safety, the machine was left in operation.

The findings cited above do not negate the fact that operator 2 commanded the closing while his colleague was still within the machine. Furthermore, they do not explain the reasons that a part of the worker’s body was present in the operation zone. The ensuing discussion explores these themes with the support of the notion of conceptual enlargement of the analysis.

#### 4. Discussion

The MAPA analysis enables description of the situation as an illusion of safety and an error trap [4]. The passage of assistant 03 through the light curtain at the entrance to the operational zone, to cover the part, was detected and it activated the system of press brakes for a determinate time period unknown to the operator who was led to feel a sense of safety. If it were activated during this braking period the two-hand control would not be obeyed, that is, the press hammer would not descend. The operational zone would have remained open.

The “behavior” of the press in this situation is the same as when the hammer-descent command is not obeyed as a function a defect presented in the two-hand control. That is, the operator sees and hears the same signs in both situations. In other words, the worker’s comprehension about the activity’s development is hindered because the system does not offer signals that help them clearly interpret which of the two situations is indicated by the machine’s behavior.

If we consider the moments of braking commanded by the light curtain and that of non-response to the hammer-descent command of the press as functioning modalities of the machine, this situation can be described as equivalent to those of an error mode [5, 6] on the part of the operator. In other words the trap is loaded and ready to strike.

In such situations, the workers commonly consider the observed behavior as equivalent to those more frequent in the system. In the accident discussed herein, this mechanism may explain that operator 02 would repeatedly activate the two-handed control given that the initial absence of a response would be due to a defect that it presented and not that, from that time, the machine would be braked by the action of the light curtain. At the end of the braking time, the press hammer descends and the pair of tools would be closed.

In addition, operator 02 and assistant 03 worked without knowing the characteristics of the functioning of the barriers installed in the machine, especially, the fact that the braking commanded by the light curtain had been previously programmed for a time interval denominated “safety time” and that, after its termination, the machine reloaded automatically, that is, it assumed the status of full fitness to activate. This fact also hampers or impedes comprehension of the functioning and the operational statuses in which the system was found. This configures a situation of cognitive vulnerability aggravated by an interface

that did not provide adequate feedback [7] and, due to failures in safety management, stimulated, in the workers, an illusion or false sense of protection.

Reviewing the work of assistant 03 with the aid of concepts related to performance levels suggested by Rasmussen [8] as well as the ergonomic studies on the behavioral differences between newcomers and experienced workers [9] it is possible to affirm that in performing the task of covering the part for the first time, assistant 03, even knowing the sequence of operations to be done, still lacked the conditions to accelerate her operational mode as would experienced colleagues. In other words, she could not obtain the skill-based performance and thus adopted a knowledge-based performance, requiring more time to conclude her work. If operator 02 had been habituated to decide the moment of triggering the closing of the pressing zone in a largely automatic fashion developed in work with experienced colleagues (skill-based performance), the greater the chances that he would do it with a rookie colleague even within the pressing zone of the machine.

Another factor capable of explaining the permanence of the assistant inside the machine for a longer time than her experienced colleagues may be the possibility of failures in positioning the plastic that would require correction. As already cited, the operational modes adopted by the newcomers in both covering the part and in correcting imperfections are slower than those of experienced workers.

The work of the assistant, initially considered simple and easy to execute, thus shows an aspect initially underestimated in the safety evaluation.

In this study the choice to not deepen the exploration of failures of barriers installed in the press was deliberate. However, the facts of both the activation by only one two-handed control and the installation of the light curtain (safety light curtain) not meeting the demands of Brazilian law [10] should be noted. Failures of curtain installation can be detected only by a professional with specific knowledge on the safety interfaces in such machines.

## 5. Conclusion

Behaviors initially interpreted as human errors in relation to the activity developed by workers can be explained distinctly with the support of the notion of conceptual enlargement of accident analysis suggested in MAPA.

The use of the conceptual enlargement notion introduces additional difficulties in accident analyses, especially in the choice of concepts useful not only to the case itself but also to the data collection and interpretation. Overcoming such difficulties demands an effort to review the training of analysis team members and, simultaneously, the creation of spaces for active participation and collaboration on the part of the workers involved in realizing the activities in question.

The findings obtained with the support of conceptual enlargement do not negate the existence of the contributions of behaviors of the workers in the accident origins, but they provide a different mode of explanation in relation to the conclusions of analyses that attribute the event to these actions. In this new approach the behaviors that fail are taken as a point of departure, as factors whose origins must be clarified in reasons that are not those intrinsic to the personality of the workers involved.

As a consequence the use of MAPA contributes to the construction of new pathways for enlarging the perimeter of interventions to prevent and protect from workplace accidents.

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