

# SEVESO ACCIDENT: AN ANALYSIS OF HUMAN AND ORGANIZATIONAL FACTORS

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## Abstract

This article is the result of work developed by some undergraduate students in the discipline of Occupational Psychology. By adopting the case study methodology, this article analyzed the industrial accident in Seveso. The objective was to understand how human and organizational factors were crucial points for such an event. The aim is to highlight the context of how the accident occurred and its technical failures, as a contribution to a better understanding of prevention and the adoption of measures in emergency situations in order to minimize the consequences and prevent future accidents from happening. It is concluded that human error does not occur due to a single person's error, but rather is the combination of several problems that accumulate until the accident culminates. In this sense, it is not possible to blame the worker who may have actually made a mistake, but it is necessary to go beyond that and look for what were also the organizational failures that can be considered the root causes of the accident.

Keywords: Industrial Accident; Seveso Directive; Seveso Industry; Operational Safety.

#### 1. INTRODUCTION

The Seveso accident is considered one of the largest industrial accidents in the history of the entire European territory. It occurred on July 10, 1976 at the Roche plant in Seveso, Italy, after an overheating of the dioxin reactor, which is widely regarded as one of the most toxic man-made chemicals (MOCARELLI et al. MAN, 1991), released into the environment through a faulty valve. The incident directly killed about 3,000 animals and caused another 70,000 to be euthanized to prevent dioxins from entering the food chain, and can be considered one of the largest chemical accidents in history. According to Freitas, Porto and Gomez (1995), amplified chemical accidents produce multiple damages in a single event and have the potential to cause

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effects that go beyond the place and time of their occurrence. This type of accident can affect long distances, and even other cities or countries, and are also complex from the point of view of risk management (FREITAS et al., 2000). Considering the size, the various consequences of accidents are difficult to assess and highly complex, and it is a huge challenge to develop prevention and control strategies, since most of these accidents have very different characteristics.

The impact on society also deserves to be highlighted, since the chemical industry is considered an industry with the potential for serious consequences, because when an accident occurs, the resulting impacts are enormous (PERROW, 1984). Dioxin can cause chronic effects that can manifest after years of exposure (AXELSON, 1993; LANDI, et al., 1997). Although no immediate deaths were reported, the release of about three tons of chemicals containing, among them, TCDD, forced the evacuation of about 600 people and more than 2000 received immediate treatment for dioxin toxicity. In the short term, severe health problems arose in those exposed (EC, 2009). In this way, Seveso experienced a dramatic increase in the number of victims of heart and vascular diseases, a doubling of deaths from leukemia and a tripling of the incidence of brain tumors. Cases of liver and gallbladder cancer increased tenfold, as did deaths from skin diseases. Two days after the accident, the factory closed and the Swiss multinational Roche paid US\$ 240 million in compensation to the victims.

According to Gomez (2000), the investigation of accidents shows the simultaneous presence of internal and external environmental problems in the manufacturing facilities involving similar technical matrices and that, from then on, they begin to require preventive policies integrated both in the issue of workers' health and in the environmental issue. However, Roche was aware of the risks of producing trichlorophenol, as there had been previous cases of industrial accidents. These risks are due to dioxin, a substance produced as a waste product during the conversion of trichlorophenol. Despite the efforts of the authorities, the physical, psychological, and environmental effects of an environmental disaster on the scale of Seveso may never be remedied.

The accident represented, in any case, the beginning of the configuration of an international policy for the prevention and treatment of major accidents, with the definition, by the European Community, of the "Seveso Directive", which prioritizes, in several passages, the right of the public to access information on the risks associated with certain types of industrial activity and the use of certain types of substances (BARBOSA, 2009).

Work-related accidents and diseases are predictable and avoidable injuries. However, although preventable, they continue to occur and have a strong impact on productivity, the economy and society. Thus, the proposed article aims to investigate the causes of the accident that occurred, in addition to analyzing the risks of accidents in workers in the chemical industries and their consequences. Because, according to Lustosa (2002), the chemical industrial genre is among the greatest causes of damage to the environment, due to the processes of production and manufacture, storage and transportation of polluting products.

This article is justified by showing the application of theoretical concepts discussed in the discipline of Work Psychology, including ergonomics, by undergraduate students in a real case. The relevance of the article is to make evident the results of this teaching work to motivate other students to apply ergonomics concepts to real accidents with high impact on society.

## 1.1. Materials and methods

This study is characterized by being a case study, with a qualitative research approach, focusing on data analysis and interpretation procedures. Thus, for Gil, (2008, p.57) the case study is characterized by the exhaustive study of one or a few objects, in order to allow their broad and detailed knowledge. In addition, according to Silveira (2009, p.31), qualitative research "is not concerned with numerical representativeness, but rather with deepening the understanding of a social group, an organization, etc."

The research was carried out on websites, texts, scientific articles, various materials, and government data available electronically, in order to obtain results that portray the reality available in the study sources. As a reference framework, the theory of organizational accident brought by the authors Llory and Montmayel (2014) was used. For these authors, analyzing and understanding complex events, such as those discussed here, means interpreting them beyond recent technical factors. Indirect, latent, or not immediately visible causes should be considered a product of the security organization.

# 2. **DEVELOPMENT**

## 2.1. The accident

Seveso's accident happened due to the organizational issues of the ICMESA company. As demonstrated by the Parliamentary Commission of Inquiry into the disaster, the accident was directly related to the lack of investment in the safety of the factory facilities (CENTEMERI, 2010).

Before analyzing the reasons for the disaster in Seveso, it is essential to observe the entire chronology up to the moment of the accident.

- In 1963: Roche becomes the owner of the fragrance and flavour company Givaudan SA, Geneva. According to Centemeri (2012, p.3) "the small chemical factory responsible for the disaster had been installed in the territory of the city of Meda since 1945, but belonged, through the company Givaudan, to the multinational pharmaceutical company Hofmann-LaRoche (hereinafter Roche), based in Switzerland";
- In 1969: Givaudan acquires the remaining capital of ICMESA, which manufactures intermediates for further processing in the Group (fragrances, flavorings, cosmetics and pharmaceuticals);
- 1969-1970 ICMESA begins the production of trichlorophenol (TCP). Givaudan needs high-quality TCP for the production of hexachlorophene, a disinfectant used in medical soaps;
- 1970 to July 1976 Increase in TCP production, all delivered to Givaudan;
- 1976 Friday, July 9 2:30 p.m. Seveso/ICMESA. Dr. Paolo Paoletti, ICMESA's production director, discusses the production program with the various foremen, including the person in charge of Building B. As usual in Building B, trichlorophenol (TCP) was to be produced. Trichlorophenol is an intermediate used in the production of the disinfectant hexachlorophene. 4:00 p.m. The TCP reaction container is filled with the various starting materials.
- 1976 Saturday, July 10 02:30 ICMESA according to the temperature diagram, the reaction is complete. 04:45 a.m. The foreman in charge gives the order to stop a distillation that is not completed. The heating is turned off and the contents of the container mixed for another 15 minutes. The last temperature measured is 158°C. 06:00 hours the night shift is over. Workers leave the factory, and only the cleaning and maintenance staff are left behind. 12:37 p.m. the rupture disc in the safety valve bursts as

a result of excessive pressure, caused by an exothermic reaction in the TCP vessel. A chemical mixture in the form of an aerosol cloud escapes into the air in a southeasterly direction. It was later learned that the mixture fell mainly on the communes of Seveso, Meda, Cesano Maderno and Desio.

It should be noted that there was a lack of communication between the company and the authorities, as it took a long time for the population to be informed of what happened. When the accident began, the threat did not appear clearly, neither to the authorities nor to the population, especially because by then the workers had become accustomed to the gases and bad smells that escaped from the factory from time to time CENTEMERI (2012, p3). At first, Givaudan engineers did their best to hide the seriousness of the accident to avoid the intervention of the authorities.

This schedule, especially in the two days that caused the accident, shows how there are people who were directly involved in some decisions that were one of the primary causes of the event. What would it have been like if these people had acted differently? It is possible that the accident did not happen. In fact, the presence of "human errors" in this accident can be identified. In other words, human factors in production were also the cause of the accident. However, it would be a mistake to focus only on these "human errors" and point to workers in the specific area where the accident happened as the main culprits.

It needs to point out that the accident resulted directly from gross negligence on the part of ICMESA (understood as an organization) in terms of safety. It can also be said that these negligences were caused by Roche's pressure to reduce production costs (CENTEMERI, 2012). At the time, Roche was not only aware of ICMESA's poor safety conditions, but the company also knew that the production of trichlorophenol generated a particularly toxic category of dioxin, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Next, some safety conditions at the organizational level were discussed.

#### 2.2. Safety conditions

According to Daniellou et a. (2010) "Human error is often invoked to explain accidents, but error is not the basic cause, it is a consequence of other defects in the organization". In this context, the lack of safety and low investment by ICMESA was fundamental for the large-scale accident. According to the HSE (Health and Safety Executive) website, there were several technical failures such as:

- *Operating Procedures.* The production cycle was interrupted, without any stirring or cooling, prolonging the realization of the reaction mass. In addition, the conduct of the final batch involved a series of failures in adhering to operational procedures. The original patent method of distillation specified that the charge was acidified prior to distillation. However, in the plant procedures, the order of these steps has been reversed;
- *Relief systems / ventilation systems*: failures in venting excessive pressures and sizing openings for exothermic reactions. The burst disc was set at 3.5 bar to protect against excessive pressure in the compressed air used to transfer the materials to the reactor. If a burst disc with a lower set pressure had been installed, ventilation would have occurred at a lower and less hazardous temperature;
- Control Systems: sensor alarms/trips/interlocks failures: loss of cooling, shaker failure. The reactor control systems were inadequate, both in terms of measurement equipment for a number of fundamental parameters and in the absence of any automatic control system;
- Reaction/product test: calorimetry methods, thermal stability. The company was aware of the dangerous characteristics of the main exotherm. However, studies have shown that weaker exotherms existed that could lead to an uncontrolled reaction;
- *Project Codes Plant*: in the nature of the dangerous releases there was no device to collect or destroy the toxic materials while they vented;
- Secondary Containment and catchpots: The overflow disc manufacturer recommended the use of a second receiver to recover toxic materials, but this was not mounted;
- *Emergency Response/Spill Control*: Had failures in the safety management system and site emergency plan. Information

about the chemicals released and their associated hazards was not available from the company. Communication was weak and failed both between the company and local authorities and within regulatory authorities.

Excessive cost cuts can result in the purchase of equipment that is inadequate for the organization's activities and in the lack of maintenance of equipment and work environments (SHAPPELL; WIEGMANN, 2000). If there is no communication between management and the team, or if it is not known who is in charge, the safety of the organization is at risk and accidents will occur (MUCHINSKY, 1997 apud SHAPPELL; WIEGMANN, 2000). The great challenge is to provide conditions for the elimination of the conditions that potentiate errors, increasing the chances of detecting and recovering human errors that will inevitably occur (REASON, 2002).

It is important to point out that failures in safety conditions should lead to improvements in technical control systems to prevent accidents. As a result of this accident, a directive was instituted which will be discussed below. If this directive would have been implemented earlier, most likely the accident would not have happened.

# 2.3. Seveso's Directive

The Seveso accident contributed dramatically to the growth of public concern about the industrial risks associated with the production of chemical substances. This event is considered an important milestone for the regulation on the prevention and control of these accidents within the European Community (EC) (EC 2007). This experience showed that there was damage of great proportions, both to public health and to the environment, accelerating the need for a regulatory response to the safety of chemical plants. According to Benite (2004), an occupational health and safety management system is a set of initiatives, embodied through policies, programs, procedures and processes. These must integrate the organization's activity in order to facilitate compliance with legal assumptions and, at the same time, connote coherence with the organization's own philosophical and cultural conception, in order to conduct its activities with ethics and social responsibility. According to Puiatti (2000), the first international experience for the prevention of expanded accidents took place in June 1982, with the publication in the European Community (now the European Union) of Directive 82/501/ECC, better known as the "Seveso Directive", which was amended by two amendments (1987/1988). Conceived as a conceptual tool, the project aimed to be a guiding element for

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industries, competent authorities and local authorities. The objective was to prevent each of these actors from approaching the risk management process unilaterally, harmonizing risk assessment methodologies, considering the consequences of the scenarios and the efficiency of the safety management of the enterprises, and also estimating environmental vulnerability (SALVI 2006, KONTIÉ, 2006). Crowl and Louvar (2001) indicate that risk assessment methods should include not only Incident Identification, but also Consequence Analysis. While the first describes "how" events can happen, the second must identify the expected expected damage as a result, including possible injuries and loss of life, damage to the environment, property damage, and damage resulting from the stoppage of activity. From this concept, mathematical techniques began to be used that allow the comparison between measurable results and standards of acceptability for them, as currently addressed in risk management processes (DANESHKHAN, 2004). According to Amendola (1998), Seveso's first Directive was strongly concerned with the generation of adequate and sufficient information about facilities from which risks of major accidents could arise, due to toxic emissions, fires or explosions, and with their respective means of control. This information should flow through all sectors that could perform some type of management over these risks, including the entrepreneur himself, the instituted public control bodies and the community that could be affected by such events. According to De Marchi (1988), the new Directive placed more emphasis on socio-organizational issues and prevention policies than on technical issues, considering that the analyses of serious events recorded since the implementation of Directive 82/501/EC referred, for the most part, to deficiencies in the management system of organizations. The Seveso II Directive confers more rights to access information, as it establishes that companies and authorities have obligations to subsidize the population with the necessary information. Instead of a reactive process, a proactive attitude is taken with practical information to society on how to proceed in the event of an accident (ROCHA JR., et.al. 2006, p.04). In this sense, the most innovative part of the directive is that contained in its Article 8, in terms of information to the public, establishing an obligation that will weaken industrial secrecy within the scope of the activities covered. At the same time, the directive creates a kind of information network between public authorities and industry and between industry and potentially at-risk parties (OTWAY, 1990; OTWAY AND AMENDOLA, 1989). The Seveso Directive has undergone some changes over time, with several revisions in which the last one was published in Directive 2012/18/EU of the European Parliament, and of the Council, also called Seveso III Directive, on the prevention of major accidents involving dangerous

substances and amending and subsequently repealing Directive 96/82/EC of the Council of the European Union (DIRECTIVE 2012/18/EU).

# 2.4. Human factors and ergonomics

As pointed out so far, the accident originated from different causes, and the improvement of technical control systems (promoted later by the Seveso Directive) would most likely have eliminated the occurrence of this catastrophic event. However, it is possible to point out that companies could ensure better levels of safety by introducing these technical systems along with a greater consideration of human and organizational factors (DANIELLOU et al., 2010). Putting rules and procedures in place is not enough if "human costs" are created as a result of some organizational decisions. In the case of the Seveso accident, we pointed out that there was a failure in the technical control systems. Even so, it is possible to point out that the accident could not have happened if the company had understood the consequences of its own organizational decisions. For example, the pressure from the Roche company to reduce production costs may have impacted on the lack of introduction of technical control systems to prevent the accident. But this pressure probably also impacted on the decisions made and the activities of its workers. At the operational level, workers can act by taking additional risks to be able to cope with impositions of the hierarchy in relation to the need to reduce production costs. This is connected to the distinction between task and activity present in the ergonomics literature (ABRAHÃO et al., 2009; FALZON, 2007). As a matter of zeal, or for some issue related to the presence of human costs (as in this case), the worker may act differently from what is prescribed by the organization. Work is a coordinated activity developed by workers to face what cannot be obtained in a task by the strict execution of the prescribed organization (DEJOURS, 2005). Thus, the organization needs to get closer to the workers to better understand their work and transform it, with organizational benefits in relation to performance and health and safety (GUÉRIN et al., 2001).

In this context, authors Kanki et al. (2010) argue that human error is not the cause of problems in a system that would be secure. In fact, it is a symptom. It is the byproduct of individuals working as a team trying to succeed in an imperfect, constrained system with limited resources. According to Areosa (2020), "accidents only occur because there are risks that precede them and that at some point materialize or materialize (occupational risks are essentially the product of the internal functioning of organizations)". Thus, the proposal is to go beyond the judgment that human error was the essential cause of the accident, looking for



#### 3. CONCLUSIONS

In the analysis of major industrial accidents, there must be a tendency to overcome what is called the "blame game" (MARTINS et al., 2012), seeking to understand the true origin of these tragedies of alarming proportions. Such events cannot be attributed solely to human errors, but rather to the failure inherent in poorly planned management. Thus, there are no ways to understand labor relations and organizational factors in the generation of accidents if traditional approaches are still motivated by a reductionist view of the simple causes of accidents. It is necessary to move away from the view of the causes associated with inappropriate behavior of workers due to non-compliance with safety standards (VILELA et al., 2012). Therefore, the organization of work needs to take into account all the human cost of its decisions so that there is a regular functioning of work in all instances.

Beyond the organizational scope, such large-scale destruction events are a direct result of mistaken planning choices, which allow the location of dangerous technological activities in inappropriate locations, where the ability to control unexpected catastrophic events is deficient or even non-existent (SMITH and PETLEY, 2009). Thus, the urgency of involving all relevant actors in decisions is highlighted, so that choices can be made that consider the different needs and perspectives involved (FALZON, 2013).

In short, through integrated approaches, such as the introduction of ergonomic analyses of work, systematic audits, continuous training and training of employees, open engagement with the local community and a careful evaluation of the location of industrial activities, the aim is to effectively minimize risks and promote transparency in the management of these issues. On the one hand, it is important to improve the technical control system, but on the other hand, it is also important to involve the main actors in the situations to be improved (in particular, the workers).

The implementation of periodic ergonomic analyses of work (GUÉRIN et al., 2001) will allow an in-depth analysis of operational processes, identifying vulnerable points and enabling corrective actions to be taken proactively. By understanding the real activities of workers, it is possible to transform work and the causes of possible accidents. In addition, the presence of audits, the proper education and training of employees are fundamental foundations for

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strengthening the safety culture, enabling them to act consciously and responsibly in the face of risk situations.

Active engagement with the local community plays a crucial role in identifying and mitigating potential hazards, as well as fostering a relationship of mutual trust between industry and society. This collaborative approach will allow for the sharing of relevant information and consideration of stakeholders' perspectives in the decision-making process.

Another essential element is to carry out a careful evaluation of the location of industrial activities. It is imperative to thoroughly consider aspects such as the proximity of inhabited areas, the sensitivity of the surrounding ecosystems, and the ability to control unexpected events. This detailed analysis will help reduce the risk of accidents occurring in inappropriate places.

In addition, offering tax incentives to companies committed to safe and sustainable practices will act as an additional stimulus for the adoption of preventive measures and continuous improvement of safety strategies. The sharing of good practices among companies in the sector will allow the dissemination of valuable knowledge and the construction of a collaborative network that works together to raise industrial safety standards.

By taking a broader and more collaborative approach, we will be better prepared to prevent future accidents, honoring the appreciation of safety, human well-being, and environmental protection in all industrial spheres. Only then can we build a safer and more resilient future for everyone involved.

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