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The biggest accidents in the chemical industry come from small mistakes that need to be investigated.

Major accidents in the chemical process industry begin with small failures that were never investigated

Major accidents in the chemical industry begin with small failures that were left uninvestigated.

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SUMMARY

Major accidents in the chemical, petrochemical and energy industries rarely come from an isolated and sudden cause. The literature on process safety demonstrates that these events are usually preceded by operational deviations, equipment failures and accidents that are available for analysis, but have not been investigated in sufficient depth. This article aims to discuss how systematic incident investigation, root cause analysis, hazard and operability studies (HAZOP) and safety culture are articulated in organizations' ability to learn before catastrophic events occur. The research adopts a qualitative approach, with a narrative review of scientific literature and documentary analysis of public investigative reports on accidents from Flixborough, Piper Alpha, Columbia, Texas City and Buncefield. The results indicate that indicators focused on occupational occupations tend to hide the process risk, that the normalization of deviation progressively corrodes safety margins and that root cause analysis methods based on linear chains produce recommended recommendations. It is concluded that the prevention of major accidents depends on the integration between the treatment of precursors, the revalidation of two perigo studies based on operational experience and an organizational environment in which the report of failures is valued.

Keywords: Process Security; Root cause analysis; HAZOP; Quase accidents; Safety culture.

ABSTRACT

Major accidents in the chemical, petrochemical and energy industries rarely result from a single, sudden cause. The process safety literature shows that such events are usually preceded by operational deviations, equipment failures and near misses that were available for analysis but were not investigated in sufficient depth. This article discusses how systematic incident investigation, root cause analysis, hazard and operability (HAZOP) studies and safety culture combine to determine an organization's ability to learn before a catastrophic event occurs. The investigation follows a qualitative approach, based on a narrative review of the scientific literature and a documentary analysis of public investigation reports on the Flixborough, Piper Alpha, Columbia, Texas City and Buncefield accidents. The findings indicate that indicators centered on occupational injuries tend to conceal process risk, that the normalization of deviance progressively erodes safety margins and that root cause analysis methods based on linear chains produce weak recommendations. The study concludes that the prevention of major accidents depends on integrating the treatment of precursors, the revalidation of hazard studies based on operating experience and an organizational environment in which the reporting of failures is valued.

Keywords: Process safety; Root cause analysis; HAZOP; Near misses; Safety culture.

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1 INTRODUCTION

The biggest accidents in the chemical process industry are usually sown immediately.
that becomes visible, causes an explosion, a fire or a toxic cloud that affects workers and
vizinhas communities. Specialized literature shows, contudo, that that moment is barely or
waste of a long journey, caused by operational deviations, equipment failures,
inconsiderate alarms and management decisions that, observed in isolation, seemed to be tolerated.
Turner (1978) called this interval the incubation period, a phase in which discrepant events
they accumulate without being perceived or correctly interpreted by the organization. The investigations
Officials conducted after the Flixborough, Piper Alpha, Texas City and Buncefield disasters
to convergent conclusions, to identify precursor sinais that were available before the
tragedy, but rather than not receiving treatment compatible with the gravity of the risk that we announced.
This article starts from the confirmation to discuss the role of systematic investigation of faults,
incidents and accidents in the prevention of major accidents in the chemical, petrochemical and
energetic. The problem that guides the study refers to the reasons for the organizations
technically sophisticated, equipped with formal procedures, certified management systems and
performance indicators, we continue to fail in the task of reconnoitring and correcting the precursors of
catastrophic events. The general objective is to analyze, based on scientific literature and
public research reports, such as accident causality models,
root cause analysis, perigo and operability studies, and a safety culture is articulated in
organizational capacity to learn before damage materializes.
The relevance of the topic is due to the fact that the main regulatory and normative references of
sector, such as the process safety management standard of Occupational Safety and Health
Administration (UNITED STATES, 1992) and the directors of the Center for Chemical Process Safety
(2007), we attribute incident investigation to a central function. If requirements exist
Formais, therefore, does not guarantee that research produces effective learning. Or text is
organized in seven development sections, which treat the distinction between process safety
and occupational safety, the evolution of two models of accidents, the meaning of two quase accidents,
the normalization of deviation, two limits of root cause analysis, the contribution of HAZOP and
role of safety culture, followed by conclusion.

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2 METHODOLOGY

The research is characterized as qualitative, exploratory and descriptive in nature, and combines two complementary technical procedures, narrative literature review and documentary analysis. TO The narrative review was designed to allow for critical discussion of a field conceptually. heterogeneous, no qual covivem contributes to chemical engineering, to engineering reliability, cognitive psychology and organizational sociology. Differently reviews systematic, this type of review is not intended to exhaust scientific production on any topic. quantify effects, but simply bring together the most influential works and confront their arguments in the light of a defined problem, or that is shown to be adequate for the purpose of relating theories of causality of accidents with research practices adopted in the industry.

The bibliographic survey was carried out in the Scopus, Web of Science, ScienceDirect and SciELO, such as the use of descriptors in English and Portuguese, including process safety, accident investigation, root cause analysis, near miss, HAZOP, safety culture, normalization of deviance, process safety and accident analysis. Foram prioritized articles published in newspapers reviewed by peers of recognized relevance in the area, such as Safety Science, Journal of Loss Prevention in the Process Industries, Journal of Hazardous Materials and Risk Analysis. Seminal works forums included independently of publication data, given their persistent influence on or field, as well as technical guides and standards prepared by reconstituted entities, among them or Center for Chemical Process Safety, or American Petroleum Institute ea International Electrotechnical Commission.

A documentary analysis focuses on official reports of investigation of major accidents, prepared by independent commissions or by governmental bodies and made available publicly. Foram examined the stories about Flixborough (PARKER et al., 1975), Piper Alpha (CULLEN, 1990), the loss of the Columbia space bus (COLUMBIA ACCIDENT INVESTIGATION BOARD, 2003), the Texas City refinery (UNITED STATES, 2007) and the Buncefield (MAJOR INCIDENT INVESTIGATION BOARD, 2008), along with the painel report independent chaired by Baker et al. (2007). Or Columbia case, external to the chemical industry, was included because its research committee developed an organizational analysis widely cited in process safety literature. These foram documents used as illustrative cases, and not as a statistical sample.

The collected material was subjected to analytical reading and organized into thematic categories defined by starting from the corpus itself, namely, the distinction between process safety and occupational safety,

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The explanatory models of accidents, or treatment of precursors and quase accidents, to normalization the deviation from organizational learning, the methods of root cause analysis, the perigo studies and operability and safety culture. It is recognized as a limitation or non-exhaustive character of narrative review of the predominance of cases occurring in English-speaking countries, such as Public documentation is more extensive. These limitations do not compromise the objective of the study, which It is interpretive in nature, but indicates the convenience of future empirical research in contexts. different industries.

3 PROCESS SAFETY AND OCCUPATIONAL SAFETY, UMA DISTINCÃO NECESSARY

Process safety is concerned with preventing unplanned releases of substances hazardous or energy sources capable of causing fires, explosions and toxic exposures, fire events, low frequency and potentially catastrophic consequences. O Center for Chemical Process Safety (2007) defines it as a disciplinary field oriented to the integrity of two systems that contain and control dangerous materials, or that involves project, operation, maintenance and management of removals. Occupational insurance, in turn, focuses on individual injuries resulting from curfews, cuts, efforts and contact with moving parts, more frequent events and consequences generally restraints to people involved. Hopkins (2009) argues that the confusion between these two domains constitute one of the most persistent sources of false sense of security in high-ranking organizations. crag.

The accident that occurred on March 23, 2005 at the Texas City refinery, in the United States, turned This is the most familiar reference to the problem. During the departure of an isomerization unit, raffinate separator tower was overloaded with hydrocarbons, or liquid escoou for a drum purge with discharge to the atmosphere and the resulting flammable cloud found a source of ignition, causing fifteen deaths and nearly 180 injuries (UNITED STATES, 2007). or painel independent chaired by Baker et al. (2007) concluded that the company evaluated its performance in security mainly by means of tax rates of registered subjects, as quais presentavam results please, as the risk associated with the processes remained without adequate and without Corresponding attention to high leadership.

An analysis by the Chemical Safety and Hazard Investigation Board revealed that the purge drum The non-accident envelope had already recorded previous episodes of hydrocarbon release, two quais only a fraction was formally investigated, and that abnormal items from the same unit

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It has also not been the subject of analysis (UNITED STATES, 2007). Hopkins (2008) dedicou um
I study inteiro ao caso eo intitulou, in a significant way, as a mistake in learning. For the author,
The organization has sufficient information to anticipate the scenario, but its structure of
incentives, its indicators and its way of distributing privileged managerial attention here that was
easily contained, to the detriment of two sinais of deterioration of the containment barriers
dangerous inventories.
The regulatory response to accidents of this nature is consolidated in the United States with standard 29
CFR 1910.119, which establishes process safety management requirements for facilities that
We handle highly hazardous chemical products (UNITED STATES, 1992). between seus
Elements are subject to process analysis, removal management, mechanical integrity and
investigation of incidents, with the express requirement to investigate only the events that
It will result in a catastrophic liberation, but also those who will be able to reason with you.
provoked. The risk-based process safety model proposed by Center for Chemical
Process Safety (2007) deepened this logic to organize twenty elements in four pillars, one two
quais specifically dedicated to learning through experience.
Measuring performance in process safety requires its own structure and practice.
recommended API RP 754, which distributes the indicators on four levels, from power loss events
containment with more serious consequences, levels 1 and 2, challenges to protection systems and
operational discipline indicators, levels 3 and 4 (AMERICAN PETROLEUM INSTITUTE,
2016). Levels 3 and 4 of the classification of the antecedent character and seek to capture the deterioration
das barriers before she becomes a liberation. Hopkins (2009) observes that the value of
indicators do not reside in the abstract distinction between antecedent and consequent measures, but rather in their
Ability to reflect the real state of two critical controls of each installation. Without investigation
consistent two events of lesser severity, no indicator system manages to fulfill this
function.

4 DA LINEAR SEQUÊNCIA O SISTEMA, A EVOLUÇÃO TWO MODELS OF ACCIDENT

The way an organization investigates an accident depends on the causality model it adopts,
even more so implicitly. The first large-scale model was presented by Heinrich
(1931), which describes the accident as a sequence of factors chained together in the manner of pieces of
dominoes, where the removal of an element would interrupt the progress of the event. Or author too

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They argued that the majority of accidents were the cause of unsafe workers,
proposition that influenced prevention practice for decades. Manuele (2011) examined
Critically examine these premises and demonstrate that they lack verifiable empirical support,
We will also lead to investigations aimed at identifying the guilty parties. Almeida (2006) decreve
similar trajectory in Brazil, where the paradigm focused on the error of workers predominated by
long time in accident analysis.

An important inflection appears in the work of Turner (1978), who analyzed dozens of stories from
British disasters and concluded that these events were not the result of anything or technical failures
isolated, more of social and organizational processes. The concept of incubation period decreases to
Phase em that small discrepant events, contrary to beliefs and norms oils on or perigo,
Accumulate without the organization noticing or interpreting them adequately. essa
Perspective dislocates the focus of the analysis of the moment of the accident for the interval that precedes, not
What relevant information circulates in a fragmented way, only ignored because we will be outside
dominant reference tables or not considered because they conflict with production goals.

Reason (1990, 1997) consolidated this dislocation to distinguish active mistakes, committed by quem
act directly on the system and whose effects are only immediate, from latent conditions, originating in
project, management, resource allocation and work organization decisions, which we can
remain dormant for long periods. The so-called Swiss queijo model represents
Defenses of a system as successive layers, each with temporary or permanent faults,
The accident is like the momentary alignment of these faults. For or author, or organizational accident
It is less of an individual action on the front line and more of a combination of latent conditions.
accumulated and triggering local circumstances, or that redirects the object of investigation to
os sistemas de gestion.

Perrow (1984) increased a structural reading in proportion to systems characterized by
Interactive complexity and rigid coupling, frequent conditions in processing plants
chemical, are subject to acids that are called normais, no sense of which interactions
unforeseen events between failures inherent to the architecture of these systems. Rasmussen (1997), on the other hand
On the other hand, the development of organizational behavior as a gradual drift in the direction of the limits of
oil performance, simultaneously driven by economic and peel efficiency pressures
search for reduction of work effort. This formulation, the margins of safety are not violated
once, but progressively consumed by local adaptations that seem to be rationalized for
burn like this in every moment.

Systemic models will deepen this vision. Leveson (2004, 2011) proposes treating security

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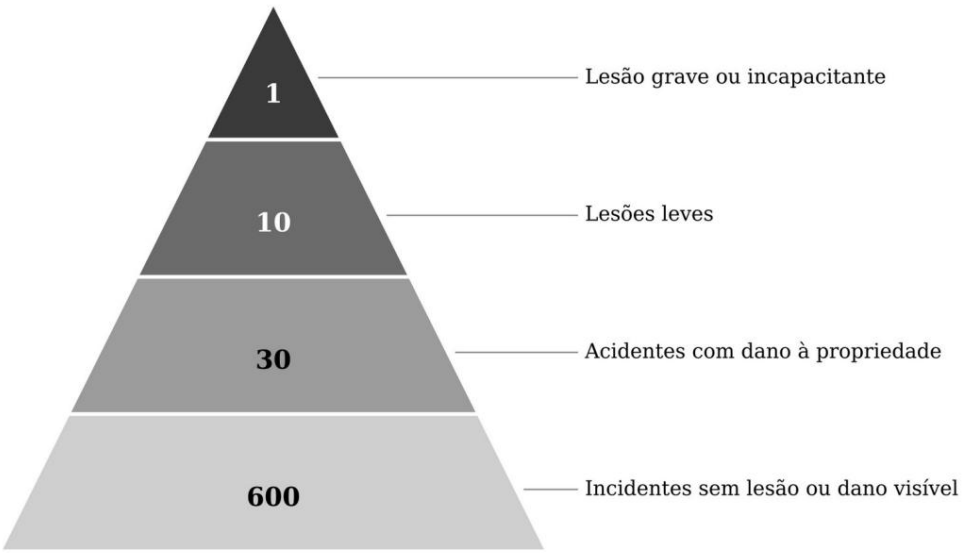
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as a control problem, not which accidents come from safety restrictions
inadequately establishes the length of a hierarchical structure that governs government regulation
This is the physical process, and not just component failures. Hollnagel (2004) develops a
typology of barriers and, subsequently, defended that the security management also considers
performance variability that allows operations to run smoothly for most of the time
(HOLLNAGEL, 2014). As a result of these contributions, research cannot
is restricted to the identification of an initiating event, so it is necessary to reconstruct the conditions
organizations that turn that event possible and provável.

5 SINAIS FRACOS AND QUASE ACCIDENTS, ON A BASE INVISÍVEL DA PIRÂMIDE

The relationship between events of different gravities was the subject of some more proposals
made up of the area. Heinrich (1931) presented a second to second ratio for each accident.
with serious injuries, there were 29 accidents with minor injuries and 300 accidents without injuries. Decades
Afterwards, Bird and Germain (1985) disclosed a revised proportion, obtained from a close analysis
of 1.7 million accident reports from approximately 300 companies, in which each
serious or disabling injury would correspond to 10 minor injuries, 30 accidents with property damage
and 600 incidents without injury or visual damage. Figure 1 represents this proportion in the form of
pyramid, configuration that became one of the two most reproduced teaching instruments in training
of insurance professionals.

Figure 1 – Proportion between events of different gravities according to Bird and Germain



Font: created by the author based on Bird and Germain (1985).

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The most productive reading of the pyramid is not the exact values, which vary according to the sector, or period and the registration criteria, but in the confirmation that the events without consequence are very more numerous than the events with damage. This volume represents an opportunity to Reduced cost learning, because it allows studying without barriers without victims.

Phimister et al. (2003) investigate accident management programs in the chemical industry and We propose a model in seven stages, which includes identification, dissemination, distribution, analysis of direct causes, identification of solutions, dissemination and resolution. The authors will observe that many organizations lose most of the value of these events only in the first stages, because deixam de reconhecê-los or de relatá-los.

Jones, Kirchsteiger and Bjerke (1999) look at a convergent conclusion to discuss the importance of story of quase accidents for the best performance in safety in installations subject to control risks of major accidents. The authors defend that based on events without consequence should be treated as a primary source of information on the effectiveness of safeguards, and not as secondary registration of irrelevant occurrences. Kletz (1993), from a similar perspective, insisted that he chemical industry rarely faces completely disconcerting risks, once mostly Two serious accidents repeat scenes that have already occurred in other plants, in other companies or in our own installation, on a smaller scale and without tragic failure.

The pyramid, however, lends itself to erroneous interpretations when applied indistinctly to process safety. A reduction in the number of minor injuries does not necessarily imply Reduced probability of explosions or toxic releases, because these events follow different causal trajectories. Hopkins (2009) and Manuele (2011) warn that they search for indicators occupations favoráveis can divert resources and attention two mechanisms that effectively produce the major accidents. The case of Texas City illustrates this dissociation, because the refinery exibia taxes of Lesões considered satisfactory during the period in which accumulated instrument failures, delays in studies of relief and release systems not investigated (BAKER et al., 2007).

The practical implication is that the relevant precursors for process safety require share the same causal path two catastrophic events that need to be avoided. small losses of containment, activation of relief devices, intervals placed in diversion, alarms corridors treated as incômodos and operações fora two project limits belonging to that category and must be classified according to potential gravity, and not just according to or actually observed result. The Center for Chemical Process Safety (2003) recommends that decide on the depth of the investigation to consider what could have happened in

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slightly different circumstances. This criterion, simple in its formulation, requires julgamento
qualified technician and organizational disposition to dedicate resources to events that we do not produce
give us.

6 NORMALIZATION OF DEVIATION AND ORGANIZATIONAL INCAPACITY OF LEARN

Vaughan (1996) cunhou a expressão normalização do desvio ao analisar a decision of launch do
Challenger space shuttle, in 1986. The author demonstrated that the erosion of two years of closure
together two lateral thrusters had been observed in previous voices and that, at each missão
concluded without loss of the vehicle, or deviation in relation to the planned performance of the project was
reinterpreted as an oil cliff. This process does not involve individual negligence or
deliberate violation of norms, more than a sequence of technically based decisions
Second, the criteria are in force, taken by competent engineers and managers. The result was
The gradual incorporation of anomalies into the repertoire of conditions considered operating standards.
An investigation into the loss of the Columbia space bus in 2003 found a similar pattern. EITHER
release of insulating foam from the external tank during the launch had occurred in
Various previous misses have passed to be treated as maintenance and schedule quests, and
Not how to protect the integrity of the vehicle. The investigative committee concluded that the causes
The organization of the accident was so relevant as to the physical cause and the similarity between
the lacks of culture that contribute to the two tragedies, explicitly going through the concept
formulated by Vaughan (COLUMBIA ACCIDENT INVESTIGATION BOARD, 2003). Or case
demonstrates that the experience of a previous accident does not, in itself, protect an organization against
by repetition of the same mechanism.
The fuel weapons industry, or the Buncefield incident, in the United Kingdom, offers
particularly instructive example. On December 11, 2005, a gas tank transferred
during the receipt of product by pipeline, forming an extensive cloud of vapor that exploded and
originated one of the two largest fires recorded in Europe during times of peace. An investigation confirmed
that the automatic level meter had experienced recurring work in the previous months and
that a high-level independent key, intended to interrupt or enchimento, found
inoperative (MAJOR INCIDENT INVESTIGATION BOARD, 2008). As repeated failures
instrument foram treated as a rotineira maintenance problem, without analysis of its implications
for protection against transshipment.

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Kletz (1993) synthesized the phenomenon in the affirmation that organizations do not have memory and that
The accidents, therefore, are repeated. Second author, as lições extracted from a serious event tend to
It will be lost as you professionally become involved in its function, it will settle or deixam to
company, and the reasons that justify certain procedures must be carried out by
that we execute you. The Piper Alpha disaster, in 1988, which caused 167 deaths in the North Sea,
It involves failures in the work permit system and communication between shifts, so that
Information on the removal of a safety valve for maintenance does not refer to the equipment that
place the corresponding bomb in operation (CULLEN, 1990).
The literature on learning from incidents seeks to explain why research does not include
It always produces long-lasting changes. Kjellén (2000) describes prevention as a system of
feedback from experience, whose effectiveness depends on the quality of the pool of data, analysis and
the implementation of corrective measures. Lindberg, Hansson and Rollenhagen (2010) propuseram um
model in chain, composed of the stages of story, selection, investigation, dissemination and prevention,
and we will show that the rupture of any element compromises the whole. Drupsteen and Guldenmund (2014),
By reviewing the literature on the topic, we conclude that learning is only completed when it has
effective change in practices, structures or organizational crenças, or that is very different from production
of a report.

7 ROOT CAUSE ANALYSIS, SCOPE AND LIMITS

Root cause analysis refers to a set of techniques aimed at identifying underlying factors.
of an unwanted event, so that the corrective actions address the origins of the problem and do not
Just about your immediate symptoms. No context of process safety, or Center for Chemical
Process Safety (2003) guides that the investigation advance the immediate causes, generally associated
due to lack of equipment or execution of tasks, due to the deficiencies in the management systems that
will allow its occurrence. The director acknowledges that complex incidents rarely cause
unique and that the expressed root cause, not singular, can induce undue simplifications. Or objective
declared and produce recommendations capable of avoiding not only the repetition of the same event, but
also of analogous events.
The methods available vary considerably in structure and depth. Or cause diagram
The effect disseminated by Ishikawa (1990) organizes possible causes in categories and encourages discussion.
in a group, regarding the two five whys technique, associated by Ohno (1997) with the production system
Toyota, seeks to reach the origin of the problem by asking successive questions. Skelet (2004)

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compared more elaborate research methods, such as barreiras analysis,
changes, a fault tree, a diagram of events and causal factors, a MORT method and a technique
AcciMap, and showed that they differ in the level of analysis, in the ability to represent
temporal dimension and even organizational and regulatory factors.
The popularity of simpler techniques contrasts with consistent criticism regarding their capabilities.
explanatory. Card (2017) argues that the five whys lead to a single linear causal chain,
The result becomes strongly dependent on knowledge and gives the perspective that it will lead to
analyze it, so that different teams can address different causes for the same event.
Peerally et al. (2017), to examine the application of root cause analysis in health services,
Identify recurring problems, such as low-quality investigations, excessive focus on
identification of a singular cause, fragilities in independence and in the qualification of the teams of
investigation and predominance of recommendations, such as additional training, lettering and
procedural revisions, to the detriment of structural changes in work systems.
Lundberg, Rollenhagen and Hollnagel (2009) analyzed the manuais de investigação de accidententes e
demonstrate that the causality model underlying each manual determines what
Researchers therefore try to find a principle that will synthesize a
expressão what you look for is what you find. The authors increase what is found here
It conditions, in turn, what is corrected. Dekker (2014) contributed to this discussion ao
Contrary to an old view of human error, which is treated as the cause of the accident, a new view,
which is understood as a symptom of deeper problems in the system. The author also warns for
It is retrospective, which leads the researcher to judge past decisions with information that does not
We are available to burn as Tomou.
These criticisms do not invalidate the root cause analysis, but indicate the conditions for it to be useful.
Investigations of events with major accident potential require multidisciplinary teams,
independence in relation to the area involved, use of methods capable of representing multiple factors
contributors and explanation of the incident model provided. Leveson (2011) proposes that an analysis
examine why each level of the control structure, from operations to high management and organs
regulators, deixou de imor as necessárias safety restrictions. Hollnagel (2004) adds that
The recommendations must be endorsed according to the nature of the barriers that we intend to breed.
strengthen, once you have physical barriers and function you tend to be more robust than you have
symbolic, such as notices and written instructions.

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8 HAZOP EA SYSTEMATIC PRECISION OF DEVIATIONS

Regarding the investigation of incidents, work on events that have already occurred, or study background and operability, known as HAZOP, seeks to anticipate deviations before they manifest.

The technique was developed at Imperial Chemical Industries, in the United Kingdom, over a decade 1960, and its first description widely disseminated in Lawley's article (1974). Kletz (1999) He dedicated an important part of his work to the diffusion of the method, which consists of dividing the installation into Let's study and apply guide words, such as “nenhum”, “mais”, “menos”, “reverso” and “other que não”, the process parameters, such as vacuum, pressure, temperature and level. For each deviation As a result, the team identifies causes, consequences, existing safeguards and recommendations.

The IEC 61882 standard establishes the principles of application of the method, including the composition of the team, as attributes of the leader and the rapporteur, to reference documentation and record two results (INTERNATIONAL ELECTROTECHNICAL COMMISSION, 2016). The effectiveness of the study depends of a multidisciplinary group that brings together knowledge of project, operation, maintenance, instrumentation and safety, led by a facilitator with mastery of technique and independence enough to question premises. O Center for Chemical Process Safety (2008) situa o HAZOP Among the main procedures for evaluating data, along with techniques such as What If, Analyze failure modes and effects and list failures, and discuss selection criteria in accordance with phase of the life cycle and complexity of the installation.

The importance of systematic assessment of perigos turned out to be evident after the Flixborough disaster, occurred on June 1, 1974 in the United Kingdom. In a cyclo-hexane oxidation plant, a Two reactors in one series were removed from operation due to lashing, and the adjacent reactors were damaged. interconnected by a temporary tubing installed without an engineering project without validation of two efforts to which it would be submerged. By this connection a large amount of cyclo-hexane is released, and The resulting cloud explosion caused 28 deaths and destroyed the facility (PARKER et al., 1975). EITHER The investigative court found that the modification was treated as a rotten intervention, without Recognize the need for engineering approval, in this case the reference is made to consolidation of the moving management procedures, second to the temporary alterations We demand the same rigor of perigo analysis applied to the original project.

The method possui limitations remade in literature. Dunjó et al. (2010), in review on the topic, apontaram o high consumption of time and resources and strong dependence on experience and composition of the team, in addition to disclosing the various adaptations developed to expand its scope, including with computational support. Baybutt (2015) presents a detailed review of the

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HAZOP, highlighting, among other aspects, that a structure based on parameter deviations does not guarantees the identification of all relevant scenarios and that the quality of the result depends Strongly equip the facilitator. Aside from these limitations, there are practical difficulties involved, as an extension of the sessions, which tends to reduce the attention of two participants and, consequently, to abrangência da análise.

The integration between HAZOP and incident investigation constitutes a frequent point neglected The North American process safety management standard determines that Perigo analyzes are updated and revalidated at least every five years (STATES UNIDOS, 1992), and this revalidation should systematically incorporate the events that occurred not period. An incident whose scene does not consist of the study reveals a lacuna in the identification of perigos, and a credited safeguard does not study that falhou in the operation reveals a premise that It needs to be a magazine. Leveson (2011) proposes perigo analysis techniques based on theory of control as a complement to traditional methods, especially in non-quais systems Interactions between components and human decisions have a determining role.

9 SAFETY CULTURE AS A CONDITION FOR RESEARCH AND LEARN

No research method produces results from events not previously reported and reported as such. conclusions cannot be openly discussed. This confirmation explains to centralidade that or concept of safety culture acquired from the end of the 1980s. Guldenmund (2000), In an extensive review of the topic, I identified a great diversity of definitions and approaches. methodological, but also a common core, which associates a culture of safety with values, Shared beliefs and budgets that guide behavior in relation to the risk. Zohar (1980), in a pioneering study carried out in industrial organizations, introduced the climate concept of security to designate the shared benefits of workers on effective priority attributed to security for the organization.

Reason (1997) proposed that a culture of effective security corresponds, essentially, to a informed culture, in which you are responsible for the system we know the human, technical and organizations that determine your safety. To achieve it, the organization needs to develop a culture of storytelling, in which people are willing to communicate errors and accidents, a fair culture, which clearly distinguishes oily behaviors from inaceitáveis, a culture flexible, capable of adapting its structure in crisis situations, and a learning culture, suitable for draw correct conclusions from the data available and implement the necessary changes. To culture

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Justa occupies a central position and does not start, because the punishment is one of the main causes of subnotificação.

Westrum (2004) formulated a typology based on the way organizations treat information. In pathological organizations, information is used as an instrument of power, More news messages are discouraged or punished and their mistakes are hidden. Nas bureaucratic, information follows formal channels, responsibilities are compartmentalized and Falhas geram local and limited answers. In the generative, in turn, information circulates Actively, the messages are prepared and valued, the responsibilities are shared and as failures trigger investigation and reform. The author argues that the quality of the flow of Information is a reliable indicator of the security of an organization, precisely because it determines If you feel like you're in trouble, you can attack them.

Hudson (2003) developed a model of maturity that describes the evolution of the culture of security in five stages, called pathological, reactive, calculative, proative and generative. In these initial stages, it is surely seen as a problem caused by workers and treated later. due to accidents. No calculative system, formalized management systems predominate and large volume of dice, without necessarily understanding what they mean. Us At higher levels, the organization begins to actively look for problems before they occur. We manifest that we treat insurance as an integral part of the business. O model tem been used As a diagnostic tool in high-risk industries, its logic coincides with the passage of a reative investigation for a gestão oriented by precursors.

The Chemical Safety and Hazard Investigation Board's report on Texas City attributed part incident relevant to deficiencies in the organization's safety culture, including cost cuts that affects maintenance and safety and the lack of effective supervision of high leadership over or process safety performance (UNITED STATES, 2007). Baker et al. (2007) We recommend that company leadership assume a direct role in promoting a culture of Positive and reliable process assurance. Hollnagel (2014) expands this discussion to suggest that organization also learn how daily functioning happens, and not just as falhas, or that presumes proximity between managers and operational reality and reconhecimento practical knowledge of front line equipment.

10 CONCLUSION

The analysis carried out in this article allows us to affirm that the major accidents in the chemical industry,

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petrochemicals and energy do not arise suddenly and are not the result of a single mistake. The reports Officials examined in the scientific literature converge to confirm that these events are preceded by prolonged periods of accumulation of deviations, during the quais a informação necessary for prevention to be available, even if it is dispersed, fragmented or underestimated structures responsible for interpreting it.

The distinction between process safety and occupational safety is revealed as a starting point essential for discussion. Organizations that evaluate their performance exclusively by tax of individual individuals we can present favorable results as regards the containment barriers of dangerous inventories deteriorate. The case of Texas City shows that inadequate indicators They are not only imperfect measurement instruments, but also guide management attention. resource allocation in directions that deixam the main cliff without treatment.

The evolution of two accident models, from the linear sequence proposed by Heinrich to systemic approaches of Rasmussen, Leveson and Hollnagel, shows that in order to understand Causality directly conditions the quality of the investigation. When the gifted model privileges o individual error, the investigation tends to enclose the identification of a person responsible and in them Training recommendations, without achieving the latent conditions that would result in the same error Try it in other circumstances and with other people.

The quase accidents and the events of low consequence constitute a source more abundant and less burdensome knowledge about the state of safeguards. Seu aproveitamento, contudo, depends on What are classified by potential gravity and what belongs to the same causal path? two catastrophic events. The pyramid of proportions, when interpreted with such care, can lead to the mistaken belief that the reduction of small injuries is enough to prevent explosions, fires and large toxic releases.

The normalization of deviation appears as one of the two most insidious mechanisms identified in review. The Challenger, Columbia and Buncefield cases demonstrate that recurring anomalies, when do not produce immediate consequences, they tend to be reinterpreted as oil conditions of operation. This process occurs through technically justified decisions based on the criteria current, or that becomes difficult to perceive from within the organization itself and reinforces need for independent review and questioning mechanisms.

Root cause analysis maintains value when applied with methodological rigor, equipment multidisciplinary, independence and explicitness of the adopted accident model. The criticisms directed The simplest techniques, especially when it comes to producing unique causal chains and Frageis recommendations indicate that the choice of the method must be proportional to the potential of

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gravity of the investigated event. Surface investigations of events with catastrophic potential
we waste precisely the most valuable learning opportunities.
HAZOP remains one of the most consolidated tools for anticipating deviations.
sector, but its effectiveness depends on the quality of the equipment, the conduct of the study and, above all, its
Continuous updating based on operational experience. The integration between the investigation of
incidents and revalidation of perigo studies transform events that occurred into information
structured on loopholes in the identification of scenes and on safeguards whose reliability was
overestimated no project or operation.
Finally, the review demonstrates that methods, standards and indicators do not produce learning in
environments in which the story of failures is disheartened, information circulates in a restricted manner
investigation is limited to attributing blame. A safety culture, understood as a set of values
The practices that determine the treatment given to information about the risk constitute a condition for
The rest of the instruments work. It is recommended, for future studies, to carry out research
empirical studies in industrial plants from different countries, with the objective of validating how these elements
It is combined in practice and four organizational steps that favor the passage of a reative management
for a gestão effectively guided by precursors.

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