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We Don't Learn Enough from Incidents: the Roots of Human Errors

Mónica Philippart*, PhD
Ergonomic Human Factors Solutions
Austin, TX 78733
*Presenter E-mail: monica@ergohfsolutions.com

Abstract

Process Safety aims to prevent and control incidents that have the potential to release hazards that could result in serious undesired outcomes. It has been widely agreed for some time now that human error is a causal factor in most accidents. Therefore, adequate human error management is indispensable for comprehensive Process Safety Management.

Regulatory requirements to consider human factors in Safety and Environmental Management Systems have motivated companies to address human error; and so, efforts dedicated to the analysis of human factors in investigations have been increasing. However, these efforts are generally not effective at reaching the root causes of the errors, leaving organizations with the false sense of security that human error is being adequately managed. We are not learning enough, particularly from offshore incidents, and as a result, we keep having incidents that would have been preventable and organizations are not able to continuously improve. Human factors needs to be taken more seriously as a discipline that requires not just a basic understanding and some tools with guidance, but competency; i.e., deep knowledge and skills that have been developed through effective practice.

This paper provides an overview of the incident investigation process, and overview of the fundamentals of human error, and discusses why, in the experience of the presenter, many organizations, while investing time and effort, don't learn enough from incidents.

Keywords: Continuous Improvement, Human Error, Human Factors, Incident Investigation, Process Safety, Root Cause Analysis.

Introduction

Specific numbers vary depending on the research, but it is generally agreed that human error is one of the main causes of industrial incidents. Some have found that 90% of the accidents that occurred in the workplace are due to human error, while others argue that 99% of accidental losses

(excluding natural disasters) begin with human error (M. Made, R.S. Taufik and Gustiyana T., 2018).

As defined by the American Institute of Chemical Engineers (AICHE), "Process Safety is a disciplined framework for managing the integrity of operating systems and processes handling hazardous substances"; i.e., Process Safety aims to prevent and control incidents that have the potential to release hazardous materials or energy through the management of relevant systems and processes.

Bridges and Tew explain that Process Safety Management in general focuses on maintaining human errors at a tolerable level because even the premature failure of equipment is caused, if investigated deeply enough, by human error. Multiple management systems are used to control human error and limit its impact on safety, environment, and quality/production (2010). Hence, comprehensive Process Safety Management requires adequate human error management.

The author of this paper has two decades of experience conducting, overseeing, evaluating and teaching incident investigation and Root Cause Analysis (RCA) in the aerospace and petroleum (conventional and unconventional drilling including both operators and drilling contractors) industries. This experience has motivated the attempt to bring to light a shortfall commonly found in investigations, even in those conducted by organizations highly motivated and committed to continuous improvement, which is that they do not uncover important lessons that could be learned were more thorough analyses completed. The author has witnessed in every case the use of renowned methodologies and tools; therefore, this paper does not offer recommendations on which to use. Also, every investigation observed was performed by sharp individuals who participated to the best of their abilities and were interested in delivering a thorough investigation; therefore, the author does not doubt that those assigned to incident investigations are interested and sharp individuals.

The objectives of this paper are to help organizations:

- realize that the incident investigations they are conducting may not be as effective as they intend and, more importantly, as they assume;
- understand what they can do to improve their investigations;
- and to encourage those who need it to make the changes necessary to maximize the benefits of their investigation efforts.

The goal is to improve the robustness of process safety and risk management, and enable more efficient continuous improvement.

The paper first provides an overview of the incident investigation process, then offers an overview of the fundamentals of human error, and finally explains the reasons why many investigations observed in the past two decades did not uncover the root causes of the incidents.

Overview of the Incident Investigation Process

Development of incidents

For the purpose of this paper, an incident refers to an event or result that is unwanted and that the organization wishes to investigate. Incidents are usually the result of a series of events that took place under certain conditions.

Events are occurrences describing discrete actions related to the incident. They include failures, malfunctions and errors. Initiating events are those that release a hazard. There are four types of events:

- Correct actions.
- No action when action is required.
- Incorrect actions (including actions that are not required)
- Failures, such as something buckling.

Conditions are inactive situations or circumstances that enable the events related to the incident. Examples are equipment that does not meet specifications, a wet surface, small font or ambiguous instructions.

Barriers are defenses against hazards and can be engineered or administrative. Engineered barriers automatically perform their function; however, administrative barriers rely on human action and compliance to prevent, detect and/or correct problems.

Figure 1. is a simplified representation illustrating that Events and Conditions lead to Initiating Events which release hazards. When barriers do not manage the hazard effectively, the result is the incident. There are numerous variations of this simple model; for example, there could be multiple events and conditions leading to the initiating event (as is usually the case), there could be multiple layers of barriers (also as is usually the case), and there could be more than one incident resulting from one initiating event.

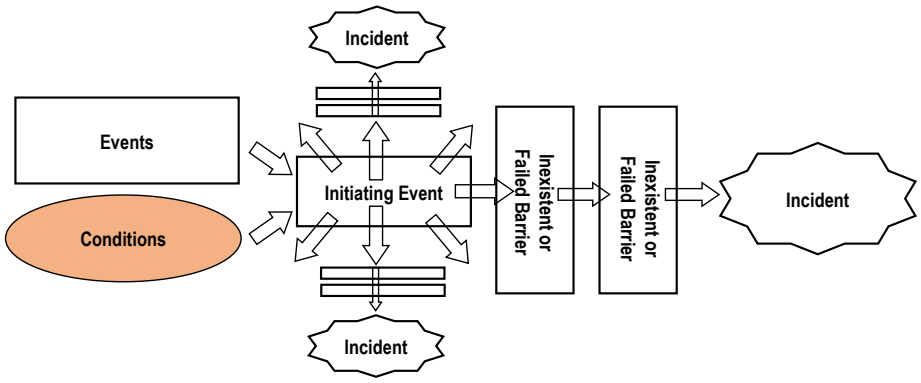

Figure 1. Development of incidents.

The investigation process

The purpose of investigations is to determine the causes of incidents to enable the development of recommendations that will prevent future incidents. Investigations contribute to Continuous Improvement.

Generally, the phases of an investigation are:

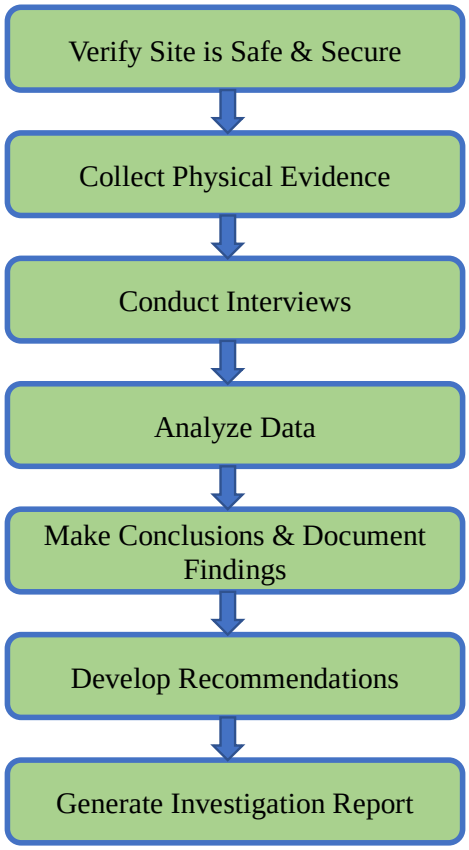

Figure 2. Phases of investigations.

The steps in these phases may overlap; for example, evidence may be gathered through the data analysis.

Root Cause Analysis

The incident investigation process evolved through the years from finding fault (what caused the incident) to understanding why. Currently, RCA is the investigation methodology of choice for most organizations in high-hazard industries. In a fact sheet published jointly by the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) in 2016, the organizations "urge employers (owners and operators) to conduct a root cause analysis following an incident or near miss at a facility" and define root cause as "a fundamental, underlying, system-related reason why an incident occurred that identifies one or more correctable system failures." The document further states that "By conducting a root cause analysis and

addressing root causes, an employer may be able to substantially or completely prevent the same or a similar incident from recurring."

RCA is a systematic and structured evaluation methodology that helps identify the immediate, intermediate and root causes of an incident. Identifying immediate causes is necessary to prevent the incident from reoccurring; but identifying root causes is necessary to eliminate or modify systemic problems so that future related occurrences may be prevented, thereby helping organizations improve their management system. Though by addressing immediate causes an organization improves, by addressing root causes the organization improves more efficiently. As Bridges and Tew affirm, "Management systems control the interaction of people with each other and with processes. [...] If management systems are weak, then layers of protection will fail and accidents will happen" (2010).

RCA helps determine:

- What happened
- How it happened
- Why it happened

Figure 3. Root Cause Analysis example.

The interactions between human activities, system organization and equipment have become more complex, and therefore the technical analysis of incident sequences have also become more difficult, requiring multidisciplinary interventions to identify the root causes.

Overview of Human Error and Contribution of its Analysis to Investigations

Human events and conditions

A human event is one in which the human performed the action in an event relevant to the incident. A human condition describes the physical, mental or emotional state of a person when that person contributed to the incident. Some human No Action and Incorrect Action events are intentional and therefore do not qualify as errors. These can then be categorized as horseplay, violations or sabotage.

When No Action or Incorrect Action events are not intentional, the events are classified as Human Error. The key is where there was intent. A person can unintentionally not perform an action that was required, unintentionally perform an action incorrectly, unintentionally perform an action that was not required, or intentionally perform an action but with unintended consequences.

For the purpose of this paper, Human Error is defined as an unintended action or the failure to perform an action as required, thereby not producing the anticipated results and potentially leading to an incident.

Human Factors discipline and basic concepts

In order to understand human error, one must first understand some basic concepts of the Human Factors discipline. Human Factors is the application of knowledge about human capabilities and limitations to system, equipment, job or environment design and development to achieve efficient, effective, comfortable and safe performance with minimum cost, manpower, skill and training.

Figure 4 illustrates how humans interact with a system. We receive (or fail to receive) information; if we receive it, we then need to be able to interpret or analyze the information prior to making a decision and, finally, act (or not) based on the decision.

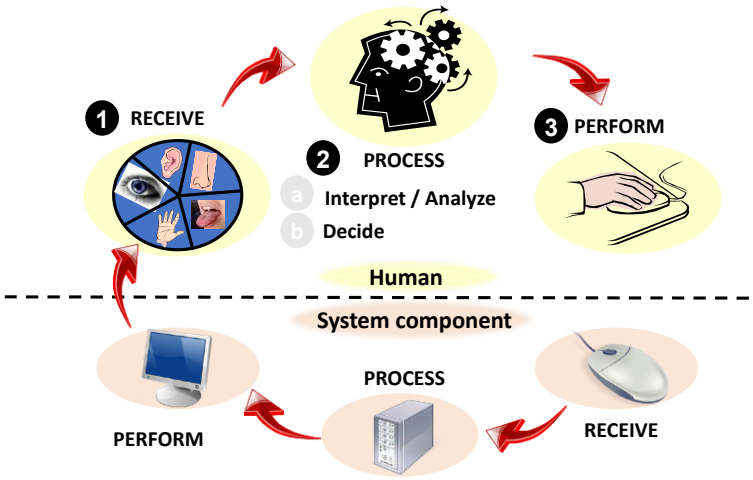

Figure 4. Human-System Interaction

This is a continuous loop, and the interactions happen with multiple system components at once, each providing different types of information that may be available through any of the senses. And

all of this happens in the context of an environment which may make it more or less difficult for these interactions to occur.

Human error can occur at any of the stages of the human- system interaction, and while interacting with anything; from interactions with tools and machines to interactions with other people, computer software, while reading documents… There are factors that make it more or less likely that these interactions are successful. These can be individual physical or mental attributes of the person relevant to the human event, or factors external to the person. Therefore, there are a myriad of sources of evidence, countless opportunities for error, and much human error evidence to collect and evaluate for possible contribution to an incident.

Human Factors contribution to investigations

As stated earlier, the incident investigation process evolved from finding fault (what caused the incident) to understanding why (Gambetti F., Casalli A. and Chisari V., 2012). Similarly, while human error used to be seen as a the cause of incidents, today it is recognized that human error is not a cause, but a symptom of underlying system management failure (Dekker, 2002), eventually leading to the realization that most incidents are in fact caused, on some level, by human error as today's complex systems often surpass the capabilities of the people who operate within them.

Future performance can be improved by understanding the reasons past incidents occurred and applying the lessons learned. In order to understand how an incident developed, it is necessary to understand the perspective of those who were involved; i.e., what led people into thinking or behaving the way they did. This requires the analysis of the human-system interactions, including the internal and external factors that influenced them – Human Error Analysis.

It is also necessary to evaluate the barriers that failed to prevent the incident. As explained earlier, administrative barriers rely on human action and compliance to prevent, detect and/or correct problems. But even engineered barriers depend on people at one point or another (in the design, selection, maintenance, installation, etc.) For these analyses too is necessary the application of human factors.

Human Factors is also valuable for the development of recommendations, particularly when attempting to prevent specific human events. Some errors can be prevented, while others can only be detected and corrected before they create incidents. Therefore, the application of human factors and thorough human error analyses are imperative for more effective prevention of incidents.

Why We're Not Learning All We Could

Though it is a generally recognized that human error plays a large role in causing process plant accidents, in contrast to the nuclear and aerospace industries, very little human error analysis is carried out in the petroleum, petrochemical and chemical industries (Taylor, J. R., 2013). Taylor believes that the main reason for this is that "it is quite hard to do, requiring considerable effort from already hard pressed engineers."
Following are explanations of what have been observed over the past two decades to be key reasons why organizations are not learning valuable information from incidents.

Inadequate use of the Human Factors expert

The Human Factors investigator should have the following specific responsibilities, in addition to any other requested by the investigation chair:

1. Identify human events and conditions that may have caused or contributed to the incident.
2. Identify and collect relevant evidence.
3. Determine why human events and conditions occurred (identify cause-effect relationships).
4. Evaluate barriers and determine why they failed or were exceeded.
5. Generate recommendations to prevent similar occurrences.

These responsibilities span all phases of the investigation process; therefore, the Human Factors investigator should participate in the process from the beginning and remain as part of the core team through the development of recommendations.

Many organizations consider the Human Factors investigator an "add on" to call upon on an "as needed" basis, which often happens after the evidence has already been collected. In some cases, the Human Factors investigator is not called at all because the team members deem that they are sufficiently capable of performing the necessary analyses.

Sometimes the Human Factors investigator never really joins the investigation team but instead is given the "relevant" information and asked to perform an analysis on specific errors (as identified by the investigation team) on the side and then submit the results to the team. There are several shortfalls with this approach, for example those related to the qualifications the people deciding a) the human events that are to be analyzed and b) the "relevant" information to provide to the Human Factors investigator. Just as in a drilling-related incident a drilling specialist would not be called in only to provide expertise for the drilling portion of the sequence of events but instead is a major participant in the investigation, knowing that human error is a main contributor to all incidents justifies the Human Factors investigator to be part of the core team.

Considering that evidence could be necessary from any of the human-system interactions potentially related to the incident, including the internal and external factors that influenced those interactions, and considering the extent and level of knowledge necessary to be able to identify such evidence, without involving the Human Factors investigator from the beginning it is unlikely that sufficient evidence is collected and therefore, no matter how good the Root Cause Analysis with the rest of the evidence, it is unlikely that the investigation arrives at the most helpful conclusions.

Unqualified Human Factors investigator

Some organizations do not assign a Human Factors expert to their incident investigations but instead either require the investigation team to consider Human Factors, or assign someone that role – usually someone with either some familiarity or interest in the Human Factors field. Senior management has been heard making comments such as "We have smart engineers. A "lunch & learn" is enough to prepare them for investigations." But performing human factors analysis not

only requires considerable effort from already hard pressed engineers; it also requires deep specialized knowledge.

Human factors is considered by some in management positions as a skill that almost anyone can apply with just a bit of training or reading if just supported by good tools. This is an appealing thought, as it would enable analyses to be performed more routinely in their organizations. There are in fact very good tools aimed at helping Human Factors investigators, but with the proper background. Those aids are not adequate substitutes for properly trained Human Factors experts knowledgeable in the necessary aspects of the discipline. Human Factors is a discipline that requires a college degree, and requiring someone without the necessary knowledge to practice it, no matter how bright the individual, is not only unfair but ineffective. The risk of having unqualified people use those support tools is that the product looks good (with classifications, nomenclature, etc.), but is likely not thorough or perhaps even correct.

It has also been observed that a person has become a "Human Factors expert" in an organization simply because he or she has been performing that role for many years; but again, without the adequate background from the start. Those individuals now feel comfortable with the terminology and tools, and confident about their expertise, and the organization has become accustomed to seeing their product; and so neither has a doubt about the quality of the investigations.

Even those with a Human Factors degree are not necessarily qualified for what should be the Human Factors investigator role inherent responsibilities. Consider **t**he medical field; as expansive and multifaceted as the intricacies of the human body, in which each medical specialty fits to serve the needs of a particular realm of care. Specialties range from allergy and immunology, anesthesiology and dermatology through diagnostic radiology and internal medicine all the way to Urology. All of them are doctors; however, a dermatologist would probably not be able to adequately diagnose a liver problem. Similarly, human factors is a systems-oriented discipline which extends across all aspects of human activity. The discipline promotes a holistic approach in which physical, cognitive, social, organizational, environmental and other relevant factors are taken into account and, therefore, is a combination of numerous disciplines, including psychology, sociology, mechanical and industrial engineering, biomechanics, industrial design, physiology, anthropometry, interaction design, visual design, user experience, user interface design, information design, kinesiology, cognitive psychology, industrial and organizational psychology, space psychology and more. Consequently, there exist domains of specialization within the discipline which represent deeper competencies in specific human attributes or characteristics of human interaction, and so, human factors practitioners come from a variety of backgrounds.

No single person can be expected to be knowledgeable in all aspects of human factors, but in order to adequately accomplish their responsibilities, human factors investigators should have basic knowledge of human physical and psychological processes, capabilities, skill levels, and limitations and, in order to effectively apply this knowledge to incident investigations, knowledge of the methods to:

- identify human events and conditions
- identify errors and types of errors
- identify factors that affect performance

- interview witnesses
- identify cause-effect relationships among events and conditions
- create timelines
- perform Root Cause Analysis
- perform barrier analysis
- draw conclusions
- generate recommendations that will reduce human error or mitigate the negative consequence of human actions.

Simply providing tools to someone with only familiarity of the Human Factors discipline cannot replace an adequately qualified person.

Ending RCA prematurely

Organizations such as the Center for Chemical Process Safety and OSHA agree that root causes of accidents are management system weaknesses, which lead to human error, which lead to accidents (Bridges, W. & Tew, R., 2010). RCA seeks more than just preventing recurrence of the exact scenario under investigation.

Most investigations (see Figure 5):
- Identify the part or individual that failed (Top dart).
- Identify the type of failure (Did not release).
- Identify a basic event or condition that caused the failure (RCTDH could not be properly cleaned and lubricated on the rig).
- End the analysis.

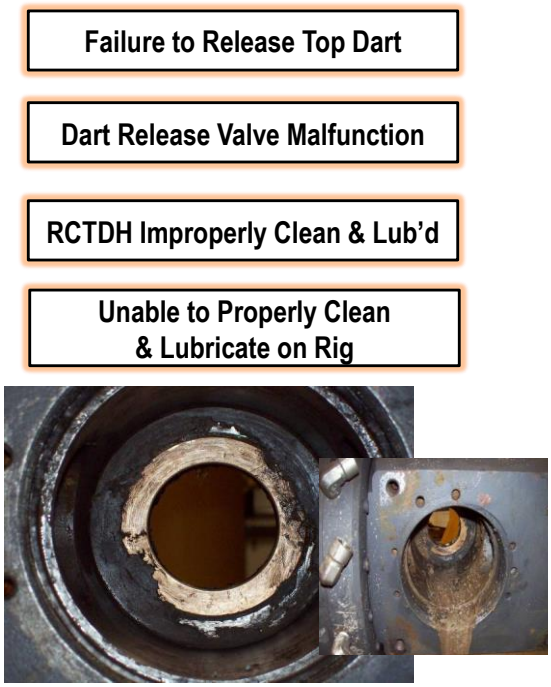

Figure 5. Typical investigation findings.

The problem with this approach is that we stop before we learn information that can help us address the underlying causes and therefore continue to have problems (not necessarily the same way or in the same areas). The analysis should continue until one the following is reached:

- an organizational factor that has control over the design, fabrication, development, maintenance, operation, or disposal of the system related to the incident. This would be a root cause.
- A problem out of the control of the organization.
- Insufficient data to continue.
- An event or condition that is not a problem.

Not analyzing near misses

Near misses are evidence of management systems weaknesses. Many organizations choose not to thoroughly investigate near misses, and so, with only a superficial investigation, only the immediate and intermediate causes of those events are identified. This results in:

- the root causes (the management system weaknesses) continue to exist,
- the organization continues to be unaware of the system weaknesses, since they were not uncovered by the investigation,
- and, perhaps more importantly, the organization now believes that the problem(s) that caused the near miss has been addressed.

Human Factors seems commonsensical

Though most engineers don't necessary feel qualified to conduct a human factors assessment, many do feel like they could at least notice if a human factors assessment is nonsense. We are human after all, so we must be able to understand how one could have made a mistake if we just look at the evidence calmly and after the fact (hindsight is 20/20, right?) In fact, what is quite easy is to unknowingly make a poor human factors assessment, and for such assessment to appear thorough and of high quality.

Human Error is popular enough that many can use the language and propose hypotheses that sound plausible and logical. Human Factors investigators who were not adequately qualified in the investigations observed were always able to produce work with which they were satisfied (i.e., they were confident that they did a great job). The results were also accepted by the rest of the investigation team and management, who were unable to realize what incorrect assumptions were made and what factors and evidence were omitted. As stated earlier, these were all sharp people genuinely trying to achieve the best result; but one doesn't know what one doesn't know.

Yes, immediate and intermediate causes are often identified and addressed (we are eliminating mosquitoes), but if we are not identifying the source of the problem (the proverbial pond), then we'll keep having incidents.

Conclusion

This paper provided an overview of the incident investigation process and an overview of the fundamentals of human error in order to provide sufficient background. The purpose was to be able to explain why many investigations do not reveal enough about what caused the incidents, even when conducted with the best effort and intentions. The objectives are to help organizations first realize that they may not be obtaining the expected outcomes from their investigations, second, understand the reason for the weakness in their investigations so they can make the necessary changes, and finally, to encourage organizations to make the changes they need.

It is not unusual to point out that investigations often address symptoms rather than problems; however, this paper intended to be more specific. For example, rather than warning "Don't make a mistake on your paper!", the aim was to specify "Check the punctuation and spelling" and then point out common punctuation and spelling mistakes.

By assigning an adequately qualified human factors investigator and having this person be part of the investigation team from beginning to end, together with an understanding that the investigation needs to arrive at causes at the organizational level (root causes) the quality of investigations can be improved and much more insight can be gained from the effort. Corrective actions will be more effective and address a broader range of issues than simply the immediate cause(s) of the incident under investigation.

The hope is that this paper opens the eyes of those who instinctively believe that by assigning a "Human Factors expert" and/or using Human Factors investigator aids they are adequately managing Human Error, and is seen as an opportunity to improve, to maximize the benefits of their investigations and make them more effective, enhancing process safety, risk management, and continuous improvement.

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