ENERGY
SAFETY
CANADA

Causal Reasoning

A Path Forward To Evolve How We Learn From Events

National Safety Association
for Canada's Energy Industry

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Safety Doesn't Clock In And It Doesn't Punch Out

It's 24/7

ENERGY SAFETY CANADA

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For over 75 years, Energy Safety Canada (ESC) has been at the forefront of safety in Canada's energy sector. Created by industry, for industry, and backed by the Workers Compensation Boards of British Columbia, Alberta, and Saskatchewan, we are the national safety association dedicated to keeping energy workers safe and driving safety improvement across the sector.

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Executive Summary

The capacity for an investigation to improve performance is dependent on the type of reasoning used by investigators. Most investigations tend to use a reasoning orientation that seeks to explain bad outcomes based on what was missing from the perceived system. However, what was not happening cannot create the outcomes that are being experienced. To understand how outcomes are caused requires a causal reasoning orientation; looking for what is present or what happened. Using a causally reasoned analysis reveals insights that are often left hidden with many traditional investigation methodologies.

This paper proposes that the role of investigations, and the reasoning orientation used by sponsors and investigators, is partly responsible for why serious events and fatalities continue to occur. By shifting the reasoning orientation to a causal one, organizations will be better positioned to develop and implement follow-up actions that create the outcomes they want.

After reading this paper, consider these questions:

1. What are the common causes that your organization has discovered through event investigations? Based on the descriptions in this paper, are they coming from a causal orientation?
2. What could this mean about the success or failure of follow-up actions?
3. How does your organization assign sponsors and when do they get involved in the investigative process?
4. What are the barriers to learning from actual and potential serious events in your organization?

Introduction

The capacity for an investigation to improve performance is dependent on the type of reasoning used by investigators. Most investigations tend to use a reasoning orientation that seeks to explain bad outcomes based on what was missing from the perceived system. However, what was not happening cannot create the outcomes that are being experienced. To understand how outcomes are caused requires a causal reasoning orientation; looking for what is present or what actually happened. Using a causally reasoned analysis reveals insights that are often left hidden with many traditional investigation methodologies.

History

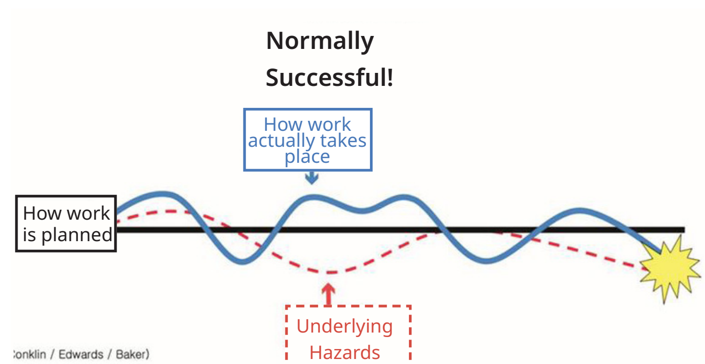
The Health and Safety community has a long history of learning from events that have evolved over the years. In the early 20th century, event investigation was rudimentary, often focusing on determining blame rather than understanding causes and preventing future events. Notable early cases include the investigation of industrial events, which were initially managed at a local level with minimal standardized procedures.

Today, event investigations incorporate advanced data analytics, simulation technologies and a greater focus on human factors. The use of black box data, for example, has become standard practice in aviation and other industries to enhance the accuracy of investigations. Modern approaches emphasize a holistic understanding of complex systems and strive to prevent events through comprehensive risk management strategies.

Problem Statement

The energy industry has a long track record of continuous improvement. In fact, the energy industry is one of the safest industries to conduct work for; however, what got the industry to this point is not what will take safety to the next level and this is particularly true for serious events including fatalities.

Currently, there are many investigation methodologies in use within the energy industry. The majority are designed to identify what organizations are not doing in comparison to how we imagine work should be done, the "black line" (Erik Hollnagel). When explanations are provided that focus on what workers are not doing, it creates the ability for quick action but leaves the understanding of how work is actually done, the "blue line" (Erik Hollnagel) hidden. These methods suggest that how work is done is irrelevant to how outcomes are created.



Investigation Biases

Many investigation methodologies aim to identify what was missing or not being conducted in accordance with a plan, or work-as-imagined. This is termed a counterfactual (Goodman, N. 1947). Counterfactuals are things that did not occur, such as "workers not following procedures" or "workers not stopping work". The reasoning orientation used to identify counterfactuals can be referred to as negative reasoning. The challenge with this reasoning bias is that it creates an illusion of cause without being causal.

Negative reasoning is quick and easy, making it an appealing approach during investigations. Since investigators already know the outcome, alternative actions that could have prevented the negative event seem like obvious and better choices. This hindsight bias fosters the illusion that different decisions would have clearly averted the issue, even though those alternatives may not have been evident at the time.

However, this reliance on counterfactuals—imagining what could have happened but did not—creates a logic trap. Since counterfactuals exist only in retrospection and never actually influenced events, they cannot serve as causal explanations. To develop sound causal reasoning, it is essential to move beyond counterfactual thinking and toward identifying the actual factors that drove the observed result.

Let us consider the counterfactual "workers failed to stop work". It is seductive to think that if only someone had stopped work before this event occurred, it would not have happened. The same can be said of the counterfactual "workers didn't identify the hazard". If only they had identified the hazard, they would have mitigated it and the outcome would not have occurred. Organizations then work on figuring out how to get the workers to "stop work before bad outcomes happen" or "identify all necessary hazards" — an impossible task.

These counterfactuals are born from hindsight. When we know what is going to happen, we can then look backwards through the lens of the outcome and identify the 'better choices' that would have created a different outcome. However, the workers who were involved in the outcome did not have that same benefit, and so made different choices. Investigators then are faced with a choice: do they judge the actions through the lens of knowledge we now have in hindsight that the workers did not have, or do they try and understand why it would make sense to the workers to make the decisions they did in foresight and learn from that.

These two biases (negative reasoning bias and hindsight bias), along with other challenges such as being too general or linear (pursuing only one line of thinking), limit investigations in their effectiveness to understand and create a new path forward.

Overcoming Investigation Biases with Causal Reasoning

Hindsight and negative reasoning biases can limit the capacity of investigations to improve performance. Causal reasoning creates an understanding of how work is done that, with intentional reflection, can enable redesigning work to get desired outcomes.

In an analysis of an event when causal reasoning becomes the reasoning orientation used, the result is a clear picture of how causes are connected in a way that demonstrates how work was done over time to get to a place no one intended. It allows leaders to identify what causal paths need to change to create a new, more desired outcome. This is called a causal analysis.

There are several considerations in developing a causal analysis:

1. Specificity: Cause statements have time, place and magnitude.
2. Necessary and sufficient: Not all data is cause. Understanding what is necessary to create the effect and what causes are sufficient to create a logically tight cause and effect diagram.
3. Alternatives: Identifying other causes or causal paths that could create the same effect based on what was present at the time.
4. Logic gates: Connecting causes together with 'ands', which mean all causes have to be present to create the effect, or 'ors', which mean all causes are present but each by themselves could create the effect.

When an analysis is causally reasoned, specific and logically connected, the picture of how work is done begins to emerge.

To help illustrate how a causally reasoned analysis can help organizations understand how work is done and begin to change the dialogue at the leadership table, consider the following example.

This Case Study is an interpretation of work conducted by Stratos LLC.

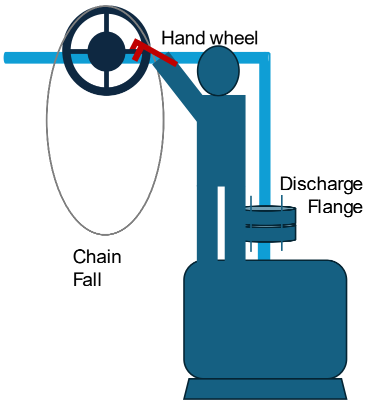
Case Study: The Broken Hand

At approximately 2 p.m. on June 17, 2020, a significant amount of propane was released from an open flange at an oil and gas facility. During the emergency response by an operator, the operator sustained an injury to his hand resulting in a broken wrist.

Prior to the event, maintenance was tasked to remove a propane pump from the unit for scheduled routine maintenance. The pump was isolated as per the isolation procedure on the prior night shift. A safe work permit was issued the next day by operations at 9 a.m. Once maintenance was ready to begin the work that afternoon, shortly before 2 p.m., they separated the pump from the suction and discharge flanges. Immediately after removing the first few bolts, maintenance observed propane coming out of the flange and evacuated the area.

A combustible gas detector subsequently alarmed in the central control room and the board operator directed the field operator to investigate the alarm. When the field operator identified that the suction line was leaking propane, he attempted to close the valve upstream of the open flange. The field operator climbed onto the pump and used an 18" pipe wrench on the hand wheel valve directly to attempt to close the valve. While applying force to close the valve, the wrench slipped off the valve wheel and the field operator's hand struck the pipe assembly behind him, resulting in a broken wrist.

The diagram below explains the set up of the pump, flange and valve and location of the operator.



A Negatively Reasoned Analysis

Initially, a negatively reasoned approach to understand why this happened was used. A team spent three days gathering data, including interviews, with multiple operators and supervisors.

Using that data, the following causes were identified as the 'root' causes:

- Operator used an improper tool: the pipe wrench was not the 'proper' tool for closing the valve. The operator should have used the chain fall instead.
- Operator deviated from good practice: the valve was designed to be closed by the chain fall. Using a pipe wrench deviated from the expected practice to close valves with chain falls.
- Valve was faulty or inappropriately used: the valve was not closing so it must have been faulty or being used inappropriately.
- Failure to learn from past experiences: it was expected that if operators used a pipe wrench to close a valve, they would bring this up as inappropriate and ask for it to be fixed before needing to use the valve again.
- Operator did not recognize the hazards: the operator was at risk when he climbed on the pump and used an improper tool to close the valve. He should have recognized that this put him at risk of falling.

From this initial investigation, leaders were put into a position where they felt their option was to fire the operator for bad judgment. In this case, this was how the organization asked leaders to behave — take the output of analysis at face value and use that for judgment of their workers. However, the operations manager of this facility did not want to fire this operator — he was considered to be his best operator. He asked for help to determine if there was anything that could be done.

The leadership team was asked: If the operator had succeeded, what would they have done? Rewarded him, they said. So, by doing work the same way but in this case achieving a bad outcome, they will fire him. The leadership team agreed to provide additional time to reason through the data with a causally reasoned orientation.

A Causal Reasoned Analysis

Aside from the focus on a broken hand and not on the serious propane release, the team uses a causal-reasoning orientation using the same data to identify the following causal paths:

1. The operator used the 18" pipe wrench on the valve upstream of the pump at that time. This was because he knew a pipe wrench would provide the necessary force to close the valve, an 18" pipe wrench was available at the pump at that specific time, and he has used a pipe wrench successfully in the past to close this valve.

Further analysis revealed that the pipe wrench had been left at that pump because some operators knew this valve was hard to close and an available pipe wrench would enable them to do their job efficiently.

2. The operator wanted to close the valve quickly at that time. The operator believed it was his responsibility to get the valve closed and if the leak continued for a few more minutes, it could lead to an ignition or facility evacuation. These last two causes are the hazards the operator did identify — the perceived risk to the plant and his colleagues.

3. The upstream valve was passing propane at that time. There were two causal paths identified through this cause:

   - The valve was passing propane by the time maintenance opened the flange. This was because the night shift operator believed he had closed the valve sufficiently during the initial isolation on the night shift on June 16. He had used the chain fall and pulled until he felt the expected resistance from the valve. He then opened the drain port on the pump and watched to see if anything leaked out. Throughout the 8-hour night shift, the drip pan below the pump remained empty. As such, he believed the pump was sufficiently isolated.
   - The closing resistance of the valve was higher than the force used to close it. The high closing resistance force had been identified by operations approximately four years prior during the past facility turnaround. Leaders had decided to leave the valve in place following the turnaround, as operations agreed they would remember the valve was hard to close and develop a way to work to ensure the valve can be closed when it was needed. The response by operations, as endorsed by leadership, was to use a pipe wrench on the valve when needed.

Learning Insights

As Dr. Todd Conklin says, "The answer to complexity is transparency," and using a causal reasoning approach that opens the door to possible learning about what lies beneath in the company.

Upon reflection, the leaders developed several critical reflections:

- A decision made by them four years ago set this event into motion. What the operator was doing was endorsed by them and had been for the past four years. This was not just about the operator; they had a part in what happened.
- The process the operators used to isolate equipment can both help verify if it is isolated and create an illusion it is isolated. This is not what the organization believed about their processes up to this point.
- Operators believe it is their job to run into dangerous situations to help protect the facility.

As a result, the leaders worked on setting up a process that would enable operators to know how their systems are isolated prior to permitting work. They also conducted a study to determine how many hard-to-close valves existed in their system and put together a plan to get them fixed.

The leadership also noted the following observations between the negatively reasoned investigation and the causally reasoned one:

- The negatively reasoned analysis put the blame squarely on the operator while the causally reasoned one told an integrated story about how work was done.
- The negatively reasoned analysis suggested it was one person who made bad decisions versus understanding that multiple operators, maintenance and leaders were part of the outcome and other operators, and leaders would make similar decisions under those circumstances.
- The causally reasoned investigation was clear and concise and those reading through it would be able to see themselves in the analysis – enabling learning rather than dismissing.

Understanding Performance and Depth of Analysis

Outcomes are often experienced through a physical system designed, built and operated by human actions and decisions. These actions and decisions are influenced by the system in which the humans work. Therefore, outcomes are always a combination of physical, human and system causes, in that order. If changes are made in the physical space but human behaviour and system remain, the capacity to improve sustainability over time is limited. Even if solutions address human behaviour but the system remains, eventually the performance will migrate back to where it has always been, and outcomes will reoccur. The system is the most powerful element of performance.

As such, investigations into bad outcomes will be most effective when the causal analysis extends into exposing the system that is governed by leaders.

Sponsorship and Setting Conditions for Success

The purpose of any investigation is to improve how work is done to achieve the outcomes leaders need most. This very idea suggests that investigations are done for a sponsor, rather than to satisfy a process or policy. As sponsors carry an accountability for improvement within the organization, they are the ones who set the vision for what a different and better future set looks like. This accountability grants sponsors authority to approve and commit resources to make necessary change.

To meet this accountability, sponsors set clear conditions for their investigation teams to help them understand why bad outcomes occurred and identify solutions that disrupt and create the outcomes they want.

These conditions are critical for several reasons:

1. Investigative work is often assigned to members of the organization with less authority than leaders who are directly connected to the operational area where the event occurred. They then need permission from a sponsor with more authority to investigate up to those senior levels.
2. The objective of this work is to adjust the systems in which work gets done. Investigation team members rarely have authority to develop improvement strategies at that level of the organization.
3. If left alone, investigators will have to decide for themselves how they are going to investigate (e.g. the type of reasoning they will use, depth, intent of the investigation, etc.,) However, this work is intended to deliver an understanding of how work gets done to leaders. Unless the leaders set the expectations for the work, how will they know if those expectations will meet their improvement needs?

When a sponsor, with a sufficient level of authority in the organization has been assigned, they are now ready to set conditions to help investigators stay focused on causal reasoning to a depth that answers their most critical questions.

Common conditions can include:

- Clear purpose and intent for the investigation.
- The reasoning orientation to be used; causal reasoning orientation if the sponsor is wanting to understand how and why the bad outcome occurred.
- Time to find data and translate that data into cause.
- Access to necessary resources such as individuals involved or specialists to explain physical mechanisms.
- Access to sponsors to help keep reasoning causal and the investigation focused on the sponsors questions.

With these conditions set in place, investigators can now work for the sponsors to discover how the organization got into the problem in the first place.

Adhering to the Fundamentals of Performance Improvement

There are six fundamentals that, if applied to the investigative work, enable performance improvement over time:

1. Causes are perceptible and specific. This means that they are present and real, compared to what is missing or what was not there. They are also specific in terms of time, place and magnitude.
2. Data and logic inform cause. There is a difference between data and cause-data helps investigators understand why an effect was caused and logic is what helps form the causal statements.
3. System governs performance. Performance is created through integrations between physical mechanism, human actions and decisions, and systemic factors such as organization structure, resources, expectations, etc. The system is what governs human behaviour and physical mechanisms. As such, if the system remains the same following an investigation, then the chance of repeat outcomes is high.
4. Learning drives change. The purpose of an investigation is to reveal how work is being done that is different from what was expected. To create change, we first must learn about the system and accept the system is real, despite our beliefs to the contrary. As such, learning is a disruptive process and must be done intentionally. Through learning, sponsors can then identify what needs to change and what can stay.
5. Actions disrupt and create. Actions are most often developed to block or prevent something from happening. However, inherently actions add something to the system as well. Understanding how they disrupt and what they will change and how is critical to improving performance.
6. Performance improvement is directly correlated to leadership involvement. When leaders engage to set conditions and provide resources, they will achieve what they need to improve performance. If leaders remain absent and allow the investigation team to manage everything, including where to act, the capacity to improve sustainably is low.

Conclusion

Through diligent safety programs and personnel, safety performance over time in the energy industry has improved; however, serious events and fatalities continue to occur. This paper proposes that the role of investigations, and the reasoning orientation used by sponsors and investigators, is partly responsible for why serious events and fatalities continue to occur. By shifting the reasoning orientation to a causal one, organizations will be better positioned to develop and implement follow-up actions that create the outcomes they want.

After reading this paper, consider these questions:

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Potential Path Forward

Causally reasoned analysis is an advanced approach to complex investigations and as such may not be applicable to all events and all health and safety personnel. It is most likely a fit for experienced investigators on their Human and Organizational Performance journey.

ESC will continue exploring causal reasoning with incremental offerings, including workshops and potential course delivery based on industry interest.

Glossary

Accountability: Refers to the responsibility and obligation of an individual, team, or organization to account for their actions, decisions, and performance. It is often thought of synonymously with culpability and discipline based on the desire to simplify and blame but should be more aligned with ownership.

Black Line: Represents the way a job is conceived at the time of planning and when processes and procedures were created. It is referred to as Work-as-Imagined.

Blame: Is the act of assigning responsibility for an error, mistake, or wrongdoing. It often involves holding someone accountable, whether fairly or unfairly, for a negative outcome.

Blue Line: Represents the way work is done in the field, reflecting the real path or method used by workers to account for variability and uncertainty in a complex environment. It is referred to as Work-as-Done.

Causal Reasoning: An approach to thinking about what happened on the day of the event and is grounded in Work-as-Done.

Counterfactual: Counterfactuals or findings are things that did not occur, such as "workers not following procedures" or "workers not stopping work". Counterfactuals exist in retrospect and never actually influenced events and therefore are not causal. This concept is connected to Hindsight Bias and Negative Reasoning.

Drift: Refers to the gradual and often unnoticed change from established safety practices due to changing conditions or pressures, leading to increased risk exposure over time. It is often the result of stable systems that have weak or no signals to provide feedback.

Error: An unintentional action that had an unintended negative outcome. In hindsight, errors are often viewed as choices or decisions when in fact they are neither as it was an unintentional action.

Event: Describes an occurrence, often the release of hazardous energy, that may or may not result in harm or some undesired circumstance. It can be used as a neutral term in place of incident or accident.

Hindsight Bias: When we know what is going to happen, we can then look backwards through the lens of the outcome and identify the 'better choices' that would have created a different outcome. This is a bias because the workers conducting the work did not have this foresight or ability to know the future.

Human Factor: Refers to the study of how people interact with systems, environments, and technology, with a focus on optimizing safety, performance, and efficiency. It considers human capabilities, limitations, and behaviors to design better workplaces, equipment, and procedures.

Human Organizational Performance (HOP): A safety philosophy from the Nuclear Energy Sector in North America, recognizing that human error is inevitable, and systems should be designed to be resilient to these errors. HOP is about making is easier to be safe and harder to be unsafe. HOP focuses on operational and organizational learning from past experiences and everyday work, emphasizing the role of leadership in creating an open environment for continuous learning. The five principles of HOP include recognizing human error as normal, understanding that blame fixes nothing, context drives behavior, learning and improving are vital, and the response to failure matters.

Learning: A process of acquiring knowledge, skills, behaviors, or attitudes through experience, study, or teaching. It involves understanding new concepts, improving abilities, and adapting to new situations.

Mistake: An intentional or deliberate action that had an unintended negative outcome. In safety contexts, it is viewed as a learning opportunity rather than a point of blame, emphasizing the need to understand the system influences and prevent recurrence.

Negative Reasoning: Involves being focused on what did not happen, often relative to Work-as-Imagined. This reasoning involves the use of counterfactuals and hindsight bias.

Red Line: Represents the presence of a hazard such as hazardous energy. It is important to note that the hazard is not fixed but moves with the changing environment.

Sponsor: As sponsors carry an accountability for improvement within the organization, they are the ones who set the vision for what a different and better future looks like.

System Failure: A failure within the system is about" broader systemic issues and system failure looks at broader systemic issues and design flaws that contribute to errors, recognizing that problems most often arise from the system rather than individuals.

Turnaround: A window of time where the facility shuts done completely and major maintenance on equipment is conducted simultaneously.

Work-as-Done (WAD): Describes the actual way work is carried out in the field, including any deviations from the planned procedures due to real-world constraints, uncertainty, and variability. It is represented by the Blue Line.

Work-as-Imagined (WAI): Refers to the way tasks and processes are planned and documented, often through policies, practices, procedures, and training materials. It is represented by the Black Line and is often not a reflection of what it takes to complete success work in a complex system.

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