The Book of Beacons: An Improved Resource for Learning Process Safety Lessons

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Abstract

Humanity has been learning from history for over 50,000 years. Why then do we share process safety incidents only to see them repeated in a few years? There is a variety of reasons for the failures to learn. Several of them will be explored and potential improvements on learning from process safety incidents will be discussed in this paper.

This paper presents the function of the CCPS *Book of Beacons* as an enhanced learning tool that improves how the lessons can be internalized to improve retention of the key messages. The Book of Beacons Project broadens the utility beyond the original CCPS Process Safety Beacons (Beacons) to other adjacent topics by providing more in-depth information about the incident, the technical and cultural causes, as well as more detailed lessons. Learning is also extended to cover which of the Risk Based Process Safety (RBPS) elements were sub-standard.

1 Introduction

Telling and repeating stories has been the primary history recording method for over 50,000 years. Around 3,000 BCE, formal written communications were developed, and recorded history began. Some cultures were better at recording history while others relied on verbal transfer of knowledge and culture well into modern times.

The chemical process industries have been recording incidents for many years but sharing only occurred if the incident received broad media or regulatory attention. Those incidents were investigated by the companies but sharing those events outside the company was inconsistent. Even inside companies, lessons from past incidents were only discussed in informal settings with little technical explanation. While a benefit to safety culture, this system lacked the attributes of organized education and permanence requisite in a learning culture.

In time, our industry learned the value of sharing not only incidents, but the technical background to facilitate prevention of similar events. Several groups enabled and facilitated better investigations and sharing of reports and findings. Among them were the U.S. Occupational Safety and Health Administration (OSHA), The U.S. Environmental Protection Agency (USEPA) the Center for Chemical Process Safety (CCPS) and the U.S. Chemical Safety and Hazard Investigation Board (CSB), and the Health and Safety Executive (HSE) in the U.K. However, written records alone do not create learning unless they are read and understood, the correct lessons are extracted from them. Most importantly, those lessons must result in sustained safety system improvements.

2. How do we learn ?

There have been volumes written about learning styles and the amount of information absorbed when using the various presentation modes:

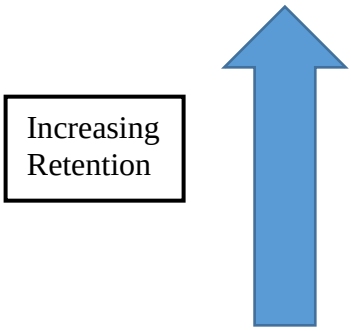
Performing the new concept (highest)

Watching a demonstration

Seeing pictures of the concept

Reading the information

Hearing the information (lowest)



In our current fast-paced work world, time is a precious commodity. While safety messages are important, they are only one part of the daily barrage of information. That said, how do we effectively and efficiently deliver these safety messages to those who need them most - those at the frontline of the process?

Unfortunately, in the petrochemical industry, the track record for learning from past events is not good. Repeated tank overfills, fires, explosions, and runaway chemical reactions are examples of failure to learn from others' mistakes. The goal of learning from others' events is to gain the information without having to experience the consequences firsthand.

CCPS has published two books that document incidents including analysis of the events. They are *Incidents That Define Process Safety*[1] and the second edition *More Incidents That Define Process Safety* [2]. These two volumes describe some of the most infamous events within the chemical industries and from outside them. A third book, *Recognizing Catastrophic Incident Warning Signs in the Process Industries* [3] provides a collection of warning signs and the incidents that occurred because those warning signs were overlooked. Then why are the lessons from these volumes failing to have a lasting impact on incidents and especially on preventing recurrences?

3. Barriers to Learning from Incidents

Why are potential lessons shared so poorly? Why are frontline employees not learning from past incidents when they <u>are</u> shared? Here is a partial list of factors that inhibit sharing and/or learning:

1. Incidents not shared internally or externally
2. Poor investigation or incomplete documentation of investigations
3. Fear of embarrassment/criticism/litigation from sharing
4. Corporate culture/politics
5. No known forum to facilitate sharing
6. Dismissal: not "our" process or industry
7. Criticism of the victim company's systems
8. A blame culture

Of these, this paper will focus on the last three factors.

a. <u>Dismissal: not "our" process or industry</u>

In the 1984 incident in Bhopal, India, a huge release of Methyl Isocyanate (MIC) caused in tens of thousands of fatalities. "We don't handle MIC; we're fine" was a phrase many colleagues and I heard from leadership. At the time, little detail was known about the event and because it happened 'over there' it was quickly forgotten. In retrospect, that response is a bit surprising since it involved one of the most respected U.S. chemical companies, Union Carbide. Further analysis of Bhopal has uncovered new and better understanding of this event which has provided additional lessons for the industry.

Even events from other industries or unique events can provide process safety lessons. The *Process Safety Beacon* has used events from many industries as examples of things that can go wrong and some lessons, we in the process industries can use. Some examples:

- A hot air balloon race ending in the middle of a chemical plant ("Mr. Potato Head Is Down!" April 2007) [4]. This Beacon explains the need for good emergency planning, even for events that are unforeseeable, such as a number of hot-air balloons landing in your chemical plant.
- A tank failure from 1919 ("The Great Boston Molasses Flood of 1919" May 2007) [5]. A catastrophic tank failure sent a tidal wave of molasses through a neighborhood in Boston. While this happened in the food industry, tank leaks and failures occur in all process industries and, even though the material stored was not hazardous, it killed 21 and injured 150 people.
- Potential injury or asphyxiation from cleaning chemicals ("Dangerous chemical reactions at home!" June 2016) [6]. In homes and commercial businesses, fatal asphyxiations have been caused by mixing household cleaning chemicals. Some of the chemical hazards we deal with on a daily basis are present outside the work environment. Chemical hazards are everywhere!

b. Criticism of the victim company's systems

This is a defense mechanism meant to deflect potential blame from ourselves. Rather than perform an internal search of the systems for the functionality lacking in the event, the blame is deflected back onto those who had the event. The goal of all incident investigations should be to determine the systemic causes of the event and to enact effective and sustainable corrective actions to prevent recurrence.
When a review of an incident focuses on criticism, the learning potential declines. When considering Bhopal, it is easy to focus on the equipment and operational deficiencies that existed instead of exploring the root causes and looking internally for similar deficiencies.
An especially important concept is that process safety is a journey toward excellence and zero incidents. No one can ever claim their systems are completely functional; there is always room for improvement. The site where the event occurred may have had excellent people and systems, but a single deficiency can defeat multiple safety systems in a heartbeat and allow the unsafe condition to initiate an event.

Criticizing other systems must consider that, some activities that were considered safe in the past have been replaced with improved systems. Before the OSHA Lock Out Tag Out (LOTO) regulation[7] it was common practice to close and tag a valve without a lock or double block and bleed when opening a line. Today, that would be unthinkable and probably result in disciplinary action.

Instead of criticizing consider, Covey's Habit #5: "Seek first to understand, then to be understood."[8]. To get the most out of incident-based lessons we need to understand the circumstances, both technical and interpersonal, before trying to determine the system failings. Only then can the real lessons be extracted and shared. From those lessons, effective system improvements can be determined and enacted.

c. A blame culture

There is a thin line between criticism and blaming, but the differences deserve mention. As noted above, the goals of incident investigations are to learn, correct deficiencies and prevent recurrence of similar events. Seeking to place blame on a person or group directly conflicts with this concept and can result in inaccurate causes and, therefore, incorrect remedial actions.

> A flash fire occurred when the operator was cleaning a blender after a batch; fortunately, the operator only received minor burns. The investigation determined that the tools used during cleaning provided the ignition sources and placed blame on the operator for using the wrong tools as specified by the cleaning procedure. When interviewed, the operator showed the cleaning procedure he had used; he was indeed using the correct tool per those instructions. In reality there were three procedures for cleaning that equipment, and there was no guidance for which cleaning procedure to use. The tool was correct for the procedure being used. Fortunately, this investigation went beyond placing blame and uncovered the real cause – poorly written instructions for determining the proper cleaning method.

What is often called the bad apple approach seeks to blame someone so they can be fixed or fired. By removing the bad apple(s) from the operation, the problem is supposed to be solved. In the example above, removing or disciplining the operator would have prevented the real root cause from being uncovered, and that event could have recurred. Are there frequently training deficiencies to be addressed following an incident? Of course, but when that is the only element that is addressed, the root cause(s) probably persists.

Another downside to placing blame is the negative impact on the process safety culture. Fear of being blamed discourages near-miss and incident reporting; potential safety improvements are missed; and confidence in the process safety systems is damaged. We all know that developing a positive process safety culture takes years, but it can be critically damaged in a few minutes.

d. Hindsight Bias.

In addition to the organizational factors listed above, hindsight bias is an individual condition. This mindset uses the advantage of hindsight. It is perfectly obvious why something happened once you know the outcome of the decision(s) leading up to the event.

"This hindsight bias makes it difficult to objectively review a case study or incident without second guessing the actions taken by those involved. The fact is we cannot 'unknow' information, so overcoming hindsight bias is perhaps more difficult that overcoming other types of bias, where knowledge that the bias is present can help to limit its impact."….

"In simplified terms this means that once we know the outcome of an event, we can see exactly what went wrong in leading to the outcome. We see this information with the benefit

of knowing the outcome, and therefore we do not see the events unfold in the context under which they occurred. This clouds our judgement with information that was not known to the people in the event" [9]

There are two papers/articles that demonstrate how easily some biases can shortcut learning from case studies.

The first is a paper explaining a study done by IChemE Safety Centre (ISC). In this study, the audience was shown an incident scenario without knowing the final outcome. When a decision point was reached, the video was stopped, and the participants recorded their decision. Across the course of the scenario, the majority of the participants made the same decisions that led to the original incident!

The second is a recent article in *Scientific American* [10], which discussed cognitive bias. The article used the term "jumpers" to describe those who make errors in decisions based on the sparsest of information. The authors conducted a study that reveals the essence of this thought process. It used a thinking game where the study group "encountered a person fishing from one of two lakes. In one lake, most of the fish were red; in the other, most of the fish were grey. The fisher would catch one fish at a time and stop only when the players thought they could say which lake was being fished. Some players had to see many fish before deciding. Others, the jumpers, stopped after only one or two." ….

"Jumpers made more errors than non-jumpers on problems that require thoughtful analysis. Consider this brain teaser: "A baseball bat and ball cost $1.10 together. The bat costs a dollar more than the ball. How much does the ball cost? Many respondents leaped to the conclusion of $0.10, but a little thought reveals the right answer to be $0.05."

What causes this "jumping" behavior? Psychologists use the terms automatic and controlled thought processes. Automatic thinking applies to problems that are easily solved (e.g., math facts); whereas controlled thinking is used where problems require more deliberation and analysis. (e.g., the square root of 20736). Others refer to this as fast and slow brain thinking.

From these studies, it appears we need to get people to consider incident lessons more thoroughly and not reject incident lessons out-of-hand.

4. How to address the barriers to retaining incident learnings

The goal is to help people learn the lessons from incidents without needing to also experience the catastrophic consequences. Demonstration is possible when there are videos or reenactments such as those produced by the CSB. Retaining the lessons from incidents can be enhanced in various ways:

- Having someone who had personal contact with the incident to add context and missing detail to the message, but these opportunities are rare.

- Presentations can be an effective learning method if they include a summary of the incident report. Retention of the messages is further increased if pictures are used and the summary discussion includes systemic deficiencies.
- Reading the report or just hearing of the incident are the least effective methods.

However, none of these methods will overcome the hindsight bias, unless some additional discussion enriches the auditory and visual messages. Some example methods for improving retention from incidents are included below.

a. Internalize the message

One way to increase the retention of the lessons from incidents may be to personalize the audience's exposure when presenting it – getting them to feel direct contact with the event. Listed below are several suggestions on how to increase understanding of an event by helping the audience personalize or internalize it.

1.Reveal missing facts of the incident by reviewing the incident report where available. Some potential discussion questions:

'If you had been there, would you have recognized the warning signs or problems that led to this event?'

'Are we vigilant about looking for near-misses and warning signs of possible incidents?"

2.Research the event looking for the safeguard failures

'What safeguards failed that allowed this event to occur?'

'How good are our safeguards and how do we know?

3.Which PSM or RBPS elements were deficient

'How effective are our process safety systems?'

'Would they have prevented a similar incident to our site?'

4. Cultural issues leading to the event

'What did our last cultural survey reveal?'

'Do we have similar cultural gaps?'

When I reread the CSB report on the Dupont phosgene incident[11], I often question whether I would have been astute enough to ask about the condition of the transfer hoses before allowing the operators to switch cylinders. With hindsight bias, the answer is a resounding YES! But in reality, it is difficult to say.

b. The Process Safety Beacon and the Book of Beacons

One of the tools CCPS has to present incidents and lessons is the *Process Safety Beacon.* For over 20 years, the Beacon has been published for a focus audience of frontline employees (operations & maintenance personnel). By design, the one-page document uses incident-based pictures or diagrams to highlight a process safety topic. It then presents key facts in the "Did You Know" section and possible actions in the "What Can You Do" section. Unfortunately, the single-page format limits the *Beacon* to around three hundred words. Also, the lessons focus only on what frontline personnel can do, not equipment or process design issues.

Some companies post the *Beacon* or send digital copies to a broad audience. Other companies take the additional step to use the *Beacon* as the basis for a process safety presentation to employees and contractors. However, to improve internalizing the lessons, additional information about the incident, equipment, or technology may be needed. This requires more research and preparation by the presenter.

In 2019, CCPS undertook a project to use the accumulated knowledge of the *Process Safety Beacons* to expand application of that knowledge. The result was the "*Book of Beacons"* which provides deeper analysis of each Beacon topic and information for safety meeting topics for the frontline workers. It can also serve as fuel for learning and discussion among other groups of employees and contractors. The intended audience extends beyond frontline employees and includes those in academic, technical, and managerial positions. The supplementary information in the *Book of Beacons* adds detail and technical information and fosters the internalization needed for improved learning and retention. The potential uses of these documents also increased due to the higher technical content.

The primary inspiration for this Book of Beacons project was the book, *Lessons Learned from the Chemical Process Safety Beacon, and the Wisdom of Accident Prevention*[12], a collection of Beacons published in 2015 by the team of Japanese *Beacon* translators.

While called a book, the *Book of Beacons* is actually a searchable collection of enhanced *Beacons* presented in the "flip book" format. That feature allows the entire library to be searched by any word the user chooses. Potentially, such a search could take the user to several *Beacons* that could be used to develop and enhance their messages to audiences from undergraduates to executives.

This project is on-going; it will take several years to convert the entire 20+ year collection of *Beacons* into the enhanced format. At the time of this paper, the first six years (2001-2006) of *Beacons* have been converted. The committees working to write and review the *Book of Beacons* entries will continue the conversion process until the entire backlog of *Beacons* are in the *Book of Beacons* format. The *Book of Beacons* is available free of charge to CCPS-member company employees and to the Members of the Safety & Health Division of AIChE.

c. Using the *Book of Beacons* to enhance process safety messages

The *Book of Beacons* Committee developed a list of potential uses for this flipbook. It is not intended to be complete, but to suggest ideas for sharing the collective knowledge from the many *Beacons*. Since this 'book' is searchable, many topics can be explored. Once the pertinent Beacon(s) are located, the user can assemble them into training materials, or an awareness campaign for an event such as a turnaround. Other example uses are

- Developing safety meeting awareness materials
- Pre-Process Hazard Analysis (PHA) incident awareness.
- Hazard reviews for Management of Change (MOC)
- Contractor safety meetings
- Incident investigation training
- Management reviews

5. Conclusions

While incident sharing has improved over time, the recurrence of incidents is a frustrating phenomenon in the chemical process industries. There are several reasons why lessons from incidents fail to reduce incidents especially those where materials and/or safety system failures are similar. One way to increase the impact of incident lessons is to help the audience internalize or personalize the messages. Helping the people see themselves in the same situation that created the incident may be the best method to improve retention of the key lessons.

The *Book of Beacons* is a new tool developed by CCPS to provide additional background information for incidents and safety messages from the *Process Safety Beacon.* This tool has many uses beyond safety messaging including preparation for MOCs and PHAs, incident investigation team training and management reviews.

When completed, the *Book of Beacons* will contain lessons from all *Beacons* to improve learning from process safety events.

The hope is that by providing additional detail to the reader/user, the lessons from past Beacons can be more effectively presented, allow the lessons to be personalized and increase the engagement of the audiences. Ultimately, the goal is to provide lessons that can be understood, and that create a lasting knowledge base for making better decisions in the future.

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