Take the FUN Out of Process Safety

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Process safety can be approached in many different ways. This article provides an unconventional way of looking at process safety that ties together wide-ranging ideas from seemingly disparate fields.

As chemical engineers, we often think of process safety in terms of process hazard analyses, risk assessments, layers of protection, personal protective equipment, and the like. This discussion of process safety borrows concepts from a wide range of areas, some of which have nothing to do with chemicals, chemical engineering, or process safety. Ideas from Leo Tolstoy, clinical psychologist Aubrey Daniels, and the German economist E. F. Schumacher, among others, are tied together in this unconventional exploration of process safety.

Leo Tolstoy and Anna Karenina

An unusual character for an article on process safety, Leo Tolstoy sets the stage for this discussion. Although Tolstoy died in 1910, just two years after the founding of AIChE, he articulated a concept in his novel *Anna Karenina* that we will consider as we begin our journey. The opening sentence of the seminal novel reads: "Happy families are all alike; every unhappy family is unhappy in its own way."

That famous line led Jared Diamond to coin the phrase the Anna Karenina Principle (AKP) in his book, *Guns, Germs and Steel: The Fates of Human Societies (1)*. Diamond extends this principle to evolutionary biology and the success or failure of civilizations:

"By that sentence, Tolstoy meant that, in order to be happy, a marriage must succeed in many different respects: sexual attraction, agreement about money, child discipline, religion, in-laws, and other vital issues. Failure in any one of those essential respects can doom a marriage even if it has all the other ingredients needed for happiness."

I believe this principle can be extended to understand many other things, among them, process safety. To paraphrase Tolstoy: Successful chemical processes are all alike; every unsuccessful chemical process fails in its own way. This statement implies that a successful chemical process must succeed at multiple things simultaneously — that is, all successful chemical processes look alike in the sense that they all succeed at the same things. This suggests some essential elements of a successful chemical process — things that all must go right for a process to succeed in the long term:

- the process must be thermodynamically possible
- the process must be sustainable, in that it:
  - meets a market need
  - meets some minimum financial criterion
  - has a consistent supply of raw materials
  - receives intellectual property protection
- the process must be legally acceptable, in that it:
  - is not specifically illegal or criminal
  - meets applicable regulatory requirements
- the process must be socially acceptable, in that it is:
  - safe (*i.e.*, it does not hurt people)
  - clean (*i.e.*, it does not adversely affect the environment).

Applied to process safety, the Anna Karenina Principle says that safety is just as important — no more, no less — as sustainability and legal acceptability to the success of a chemical process, as all successful chemical processes have to succeed at all of these elements consistently, if not simultaneously. This conclusion necessitates a cultural

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change, not only on the part of business managers, but on the part of process safety professionals as well.

A cultural change

In its report "Corporate Governance for Process Safety: Guidance for Senior Leaders in High Hazard Industries" *(2)*, the Organisation for Economic Co-operation and Development (OECD) describes the importance of safe operation:

"Safe operation and sustainable success in business cannot be separated. Failure to manage process safety can never deliver good performance in the long term, and the consequences of getting control of major hazards wrong are extremely costly."

If effective process safety management is so beneficial, why do leaders not practice it in the short term? Many have asked different versions of this question in other venues:

- Why do people smoke?
- Why do people use drugs?
- Why don't people wear seat belts?
- Why don't motorcyclists wear helmets?

The answers to all of these questions rest on a behavioral fact that some would rather ignore: There is often a short-term benefit for not doing what will benefit us in the long term. For example, smoking and drug use produce short-term pleasure for the users. In the same vein, minimizing process safety can produce tangible short-term benefits (*e.g.*, profits, bonuses, and promotions) to the nonpractitioners. Thus, we must overcome a huge cultural hurdle.

Cultural changes require behavioral changes. Therefore, some behavioral-based safety principles must be applied to process safety. How do we apply a behavioral model appropriately to process safety, without losing focus on the unique aspects of process safety?

According to Aubrey Daniels *(3)*, a clinical psychologist and founder of Aubrey Daniels International, an Atlanta-based company that applies scientifically proven laws of human behavior to improve business performance:

"People are the most important element of every organization. With the complex challenges facing American business leaders every day, the science of human behavior cannot be ignored. Rather, it must be the starting place for every decision we make, every new technology we apply, and every initiative we employ."

At the core of Daniels' approach is the ABC Model, where A stands for antecedents, B for behaviors, and C for consequences. Antecedents create favorable circumstances for a particular behavior to occur once. Consequences are the outcome of a behavior. Daniels suggests that consequences, perceived or previously experienced, play a significant role in managing future behavior (*i.e.*, shaping decision-making behavior).

Consequences can be characterized by three dimensions:

- timing — will the consequence occur immediately (I) or at some time in the future (F)?
- probability — is the probability of the consequence occurring certain (C) or uncertain (U)?
- type — is the consequence positive (P) or negative (N)?

Thus, consequences can be Immediate, Certain, and Positive (ICP), or Future, Uncertain, and Negative (FUN).

The vital cultural change requires that the FUN be taken out of process safety. The consequence of taking the FUN out would be that process safety incidents are prevented early, and willingly, because the managers making resource decisions clearly see the immediate, certain, and positive benefits of investing in projects that result in improved process safety. The consequences of leaving FUN in is that skeptical decision-makers may choose to not make an investment because they cannot see its benefit.

Changing our thinking

Taking the FUN out of process safety will necessitate a change in the way most chemical engineers think. E. F. Schumacher, a German ex-patriate who lived in England, describes two types of thinking in his influential book, *Small is Beautiful: Economics as if People Mattered (4)*. These modes of thinking, as defined by the British psychologist Liam Hudson, are convergent and divergent.

Convergent thinking involves finding the one unique solution to a problem by analyzing material from a variety of sources. This kind of thinking is particularly appropriate in science, math, and engineering. Divergent thinking, on the other hand, starts with a single goal (or stimulus) and theorizes multiple successful outcomes that might result from the same starting point. This type of thinking is more suited to artistic pursuits.

To succeed at taking the FUN out of process safety, we have to think divergently. Divergent thinking is needed to break the stereotypical there-is-only-one-correct-solution mindset that engineers often have.

One way to do this is by taking a different look at the familiar, because the answer may depend on things that do not directly deal with process safety. After the end of World War II, General Dwight D. Eisenhower, Supreme Allied Commander in Europe who went on to become U.S. president, was asked what weaponry was the most critical in the successful invasion of Europe. His answer was *(5)*:

"Four … pieces of equipment that most senior officers came to regard as among the most vital to our success in Africa and Europe were the bulldozer, the Jeep, the 2½-ton truck, and the C-47 airplane. Curiously enough, none of these is designed for combat."

Just as Eisenhower attributes his war success to items not typically thought of as weapons, I believe nontraditional ideas will contribute to process safety.

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Take the FUN out of process safety

This new way of thinking can be used to discuss the FUN elements introduced earlier. One way to look at process safety through a different lens is to tie it to reliability — a metric and its associated techniques that keep the plant running and that are not normally associated with process safety. Process safety and reliability are at opposite ends of the same risk continuum — reliability deals with higher-probability, lower-consequence events, whereas process safety addresses the low-probability, high-consequence events. By preventing the lower-consequence ones, you will, as a natural result of your efforts, also significantly reduce the likelihood of higher-consequence events. While the result of reliability projects (*e.g.*, increased production, or reduced downtime and maintenance costs) may have nothing to do with process safety, they can achieve the desired process safety improvements by mitigating incidents.

Turning future into immediate. Framing process safety as a reliability problem shifts our thinking away from future consequences that will occur at a later date to immediate consequences. Instead of looking for and addressing possible events that could happen, say, next month or next year, engineers can go after the day-to-day higher-frequency, lower-risk events. This can have immediate benefits for the bottom line, including higher productivity, less downtime, and fewer adverse environmental impacts.

Turning uncertain into certain. Thinking of process safety in terms of reliability also changes our focus from uncertain potential consequences to certain ones. Unlike process safety issues, which may or may not occur (uncertain), reliability issues (*e.g.*, leaks, corrosion, etc.) are readily recognized as things that will happen eventually (certain).

The certainty of a reliability problem can be backed up with data through the use of better metrics. Better metrics — both leading and lagging — play a critical role in turning uncertain into certain. Fortunately, thanks to evolving technology, previously inaccessible data are now available. For example, distributed control systems (DCS) capture and analyze large amounts of process data. However, the ability to capture data is only half the battle. Making sense of the data is the other half, and this requires the development of innovative, meaningful measures. A baseball analogy would be the difference between runs produced, which is the real measure of a player's success, and runs batted in (RBI) or batting average statistics, which are not as meaningful.

Turning negative into positive. Spending money to prevent process safety incidents often has negative connotations, because such an expense may be viewed as spending money on something that might never happen instead of on immediate issues that need attention and investment. Approaching process safety as a reliability problem turns this around and puts the emphasis on immediate and certain benefits of investing in process safety projects. This creates a positive perception for management.

Continue to seek solutions

An article on nuclear power in *The Economist (6)* included the following statement: "Safety requires more than good engineering. It takes independent regulation, and a meticulous, self-critical safety culture that endlessly searches for risks it might have missed."

This endless searching applies to process safety and is at the core of divergent thinking. Safety requires that even when a solution is found, engineers must continue to look for what has been missed or how something can be done better.

The OECD *(2)* provides a relationship between the need for endless searching and reliability (and thus process safety as it is defined in this article) in the following definition of high-reliability organizations: "A high-reliability organization has been defined as one that produces product relatively error-free over a long period of time. Two key attributes of high-reliability organizations are that they:

• have a chronic sense of unease, *i.e.*, they lack any sense of complacency. For example, they do not assume that because they have not had an incident for ten years, one will not happen imminently.

• make strong responses to weak signals, *i.e.*, they set their threshold for intervening very low. If something doesn't seem right, they are very likely to stop operations and investigate. This means they accept a much higher level of 'false alarms' than is common in the process industries."

To allow for appropriate strong responses, weak signals have to point in the right direction. If not, we could be endlessly searching in all the wrong places. This reinforces the need for reliable, believable, actionable metrics.

The economist Milton Friedman said *(7)*, "Only a crisis — actual or perceived — produces real change. When that

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crisis occurs, the actions that are taken depend on the ideas that are already lying around. It is worth discussing radical changes, not in the expectation that they will be adopted promptly but for two other reasons: One is to construct an ideal goal, so that incremental changes can be judged by whether they move the institutional structure toward or away from that ideal. The other reason is very different. It is so that if a crisis requiring or facilitating radical change does arise, alternatives will be available that have been carefully developed and fully explored."

Wrapping up

Here are some tips for thinking about and implementing process safety.

• Think divergently — there are many paths to success, and we certainly have not found them all.

• Set an ideal goal, and test everything you do against it to see if your actions are moving you in the right direction.

• Be prepared for the crisis, so that you know what alternatives exist and how you would implement them.

• Develop a self-critical structure, in which you routinely examine your practices for deficiencies and improvement opportunities, rather than wait for an external audit. Accurate, believable metrics are one key to success — you have to be looking for the needle in the correct haystack.

Why? So we can take FUN out of process safety. CEP

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