WHITE PAPER

Incident Investigation (Part 2): The Value of Investigating Near Misses

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Incident investigation, as we have demonstrated elsewhere, is a powerful tool in reducing risk and preventing disasters. However, investigation of incidents or near misses without proper methodology and follow-up is not sufficient to reach process safety goals. At the same time, investigating near misses is a very powerful lever in an effective process management system.

Incident investigation: learning from incidents

This quotation is attributed to Confucius and dates back approximately twenty-five centuries. From a process safety point of view in which wisdom is preventing industrial disasters, it certainly rings true. Take, for instance, the twenty elements of the Center for Chemical Process Safety (CCPS) risk-based process safety management system, grouped by DEKRA into seven workstreams (Table 1).

> "By three methods we may learn wisdom: first, by reflection, which is noblest; second, by imitation, which is easiest; and third by experience, which is the bitterest."

Considering this framework in light of Confucius' assessment, "Hazard Identification and Risk Analysis" would clearly best represent "learning by reflection." Indeed, process safety involves methodologies such as HAZOPs, LOPAs and others to identify potential hazards and evaluate the risks of a plant or process. In all of these methods, thought and study play a central role.

"Compliance with Standards" is a good example of what Confucius calls "imitation." Designing a plant or process based on standards and regulations is tantamount to imitating practices carried out in the past with positive results, which are therefore deemed safe.

Workstream	CCPS Elements
1. Capability	> Compliance with Standards > Process Knowledge Management > Process Safety Competency > Training and Performance Assurance
2. Incident Response	> Stakeholder Outreach > Emergency Management > Incident Investigation
3. Risk Management	> Hazard Identification and Risk Analysis
4. Asset Integrity	> Asset Integrity and Reliability > Management of Change
5. Accountability	> Measurement and Metrics > Auditing > Management Review and Continuous Improvement
6. Operations	> Operating Procedures > Safe Work Practices > Operational Readiness > Contractor Management > Conduct of Operations – Operational Discipline
7. Culture and Organization	> Process Safety Culture > Workforce Involvement

Table 1. Workstreams and CCPS elements

And what about "learning by experience"? "Incident Investigation" is its process safety counterpart. And it is certainly the bitterest, since investigations are carried out following undesirable events, both large and small. Ultimately, incident investigation is a principal part of how organizations learn from the incidents they experience.

When incident investigation isn't enough

On September 21, 2001, an ammonium nitrate explosion occurred at the AZF fertilizer factory in Toulouse, France. It was later estimated that the power released was equivalent to 20-40 tons of TNT, and nearby observatories recorded the blast as 3.4 on the Richter scale. Steel girders were found 3 km away, and the noise could be heard at a distance of 80 km. The incident resulted in 29 fatalities, and more than 2,500 injuries. Insurance companies paid damages in excess of 1.5 billion euros.

Is this accident unique, unprecedented or unforeseeable? Hardly. Table 2 summarizes similar events reaching back to 1905, some of which have been thoroughly investigated, as their publicly available reports attest. From the data, we can easily calculate an approximate frequency of one accident every three years, and an average of 71 fatalities per incident. Surely, by 2001, the lessons on the risk associated with ammonium nitrate should have already been learned.

The takeaway seems to be that investigating incidents doesn't suffice in and of itself as a preventive measure, although performing a high-quality investigation is clearly a pre-requisite to learning something. If, however, the only outcome is an impressive-looking report on an office shelf, a crucial opportunity has been missed. Any investigation must be followed up with actual improvements in the systems and behavior of the organization and the people within. In fact, the CCPS elaborates on its recommendation of

Country	Place	Date	Fatalities
Spain	Estaca de Bares	6/29/1905	0
United Kingdom	Faversham, Kent	4/2/1916	115
United States	Morgan, New Jersey (now Sayreville)	10/4/1918	100
Germany	Kriewald	7/26/1921	19
Germany	Oppau	9/21/1921	561
United States	Nixon, New Jersey (now Edison Township)	3/1/1924	20
United States	Muscle Shoals, Alabama	4/4/1925	0
Belgium	Tessenderlo	4/29/1942	189
United States	Texas City	4/16/1947	581
France	Brest	7/28/1947	29
–	Red Sea	1/23/1953	0
United States	Roseburg, Oregon	8/7/1959	14
United States	Traskwood, Arkansas	12/17/1960	0
Australia	Taroom, Queensland	8/30/1972	3
United States	Kansas City, Missouri	11/29/1988	6
Papua New Guinea	Porgera Gold Mine	8/2/1994	11
United States	Port Neal, Iowa	12/13/1994	4
China	Xingping, Shaanxi	1/6/1998	22
France	Toulouse	9/21/2001	31
Spain	Cartagena, Murcia	1/1/2003	0
France	Saint-Romain-en-Jarez	10/2/2003	0
North Korea	Ryongchŏn	4/22/2004	162
Romania	Mihăilești, Buzău	5/24/2004	18
Spain	Barracas	3/9/2004	2
Mexico	Monclova, Coahuila	9/10/2007	40
United States	Bryan, Texas	7/30/2009	0
United States	West, Texas	4/17/2013	15
Australia	Wyandra, Queensland	9/6/2014	0
China	Port of Tianjin	8/12/2015	173

Table 2. Ammonium nitrate accidents

incident investigation with instructions such as "Follow Through on Results of Investigations."[1] Additional features include: [2]

- Resolve recommendations.
- Communicate findings internally.
- Communicate findings externally.
- Maintain incident investigation records.

Implementing change by following through on investigation results and resolving recommendations is integral to the CCPS element "Incident Investigation." If no change occurs, the element implementation is incomplete; it is only on the basis of these modifications and improvements that an organization can truly say it has learned from an incident.

Near miss investigations sweeten the learning process

Investigating major events and identifying root causes, while necessary, is also very difficult. To this day, for instance, none of the several investigations into the AZF catastrophe has come up with a plausible explanation. Often, evidence is completely destroyed and individuals' willingness to be truthful about events leading to a major incident suffers in the face of legal fallout.

One way to learn by experience without the accompanying bitterness is to investigate near misses — that is, any event that could have ended up as a major accident had something not saved the day. This "something" is often a safeguard, but sometimes it is sheer luck. We see examples of the former on a regular basis: a chemical reactor suffers a runaway reaction, pressure increases, but a well-designed rupture disc bursts, preventing the pressure in the reactor to continue to climb to hazardous levels. This, indeed is the reason safeguards are designed. Unfortunately, we also see many instances of luck as the only factor averting a major disaster. Consider, for instance, an incident at Chernobyl's reactor number 1, which occurred several years prior to the infamous event at its sibling reactor 4. The only difference between the two incidents, aside from the tragically diverse consequences, were the prevailing operational conditions at the time each took place.

In addition to the relative ease in finding evidence and the increased willingness of witnesses to talk, there is another significant advantage to investigating near misses: they simply happen more often than major events. This means the opportunities for learning are numerous and at are available at little or no cost.

Heinrich's pyramid,[3] a useful construct for describing reality, but not predicting it, is shown in Figure 1 as modified by Frank E. Bird.

The graphic shows that 10 serious incidents (not even a fatality!) occur for every 600 near misses. This means that there are sixty times more opportunities to learn from investigating near misses than from investigating serious incidents. If your investigation delves deep to identify root causes, those having to do with failures in key principles and essential features of the process safety management elements, the findings can be applied to multiple hazardous scenarios. Let us assume that 8 is a reasonable multiplier in this case. Let us also assume that you decide to share your information with peers (other sites of the same company, other companies in trade associations…); 20 seems a reasonable number. If you do all of this — investigate near misses, apply findings wherever they are applicable and share the information — the opportunities to learn, as compared with only investigating serious incidents, are multiplied by 9,600 (8 × 60 × 20)!

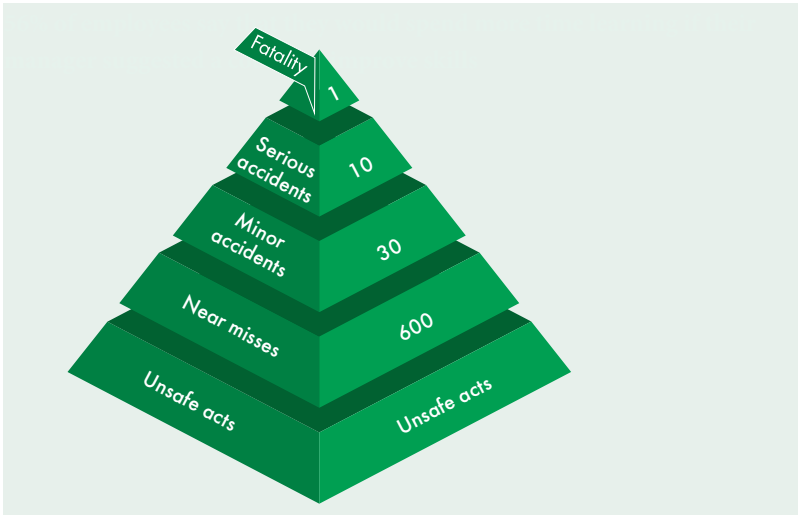

Figure 1. Heinrich's pyramid (Frank E. Bird version)

1 The CCPS defines key principle as "a part of a [risk-based process safety] element, which is often generic to all elements because of the nature of how management systems are defined [...]. For example, almost all elements include a key principle called maintain a dependable practice, which is further expanded into essential features and work activities that help ensure that appropriate actions are undertaken to provide the required level of dependability for activities related to the particular element."

2 The CCPS defines essential feature as "a set of activities or actions that help support a key principle of a [risk-based process safety] element (e.g., involving competent personnel is one essential feature that is required to maintain a dependable practice within most management systems)."

3 Heinrich, HW. Industrial Accident Prevention: A Scientific Approach. McGraw-Hill, 1931.

If these figures seem overly optimistic, consider the implications even when we do not investigate every near miss, and admit that investigations will hardly be perfect. To play it safe, we will divide our previous result by 10. Still, by properly investigating near misses, the opportunities to prevent serious incidents are multiplied by 1,000. Process safety management practices do not typically yield such multiplicative results, and, importantly, this is not magic, but rather the appropriate implementation of key principles and essential features associated with "incident investigation" as described in the CCPS framework.

Proper implementation of incident investigations

When properly implemented, learning from incidents, whether your own or others', is a very powerful tool to prevent major process safety events. While most organizations have incident investigation processes in place, evidence shows that the lessons ostensibly learned during investigations seldom take root, resulting in repeated accidents. For instance, ammonium nitrate explosions, each with an average of 70 fatalities, have been happening once every three years since the early 20th century. These statistics reveal that proper implementation of the "incident investigation" process safety management element has not occurred, most likely as a result of a failure to follow through on the changes thorough implementation would require.

In addition to conscientiously abiding by all of the features that incident investigation encompasses, treating near misses as valuable sources of information amplifies opportunities for learning. A near miss is much less fraught than a full-blown disaster: evidence is usually easier to find; people are more willing to be frank; and greater frequency means learning can happen more often and more consistently.

A focus on thorough investigations and appropriate follow-up combined with increased attention on near-miss events can translate into safer operations and fewer tragedies.

PIETER DE KORT

Pieter de Kort has accumulated 25+ years of experience in the process industry gained through various positions in process safety for large chemical companies. His experience has given him a broad know-how for tackling process safety issues. His main areas of expertise are process safety management, incident investigation, due diligence studies, chemical reaction hazards, HSE auditing / process safety auditing, process hazard analysis (PHR, HAZOP, What-If) facilitation and he is an experienced facilitator and trainer.

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