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Safety, expectations and exceptions

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ABSTRACT: One hears, very often, a senior person in an organisation saying: *Safety is our number one priority* with further statements that all employees are expected to work safely. Indeed, such sentiments were expressed by a senior person working for the large construction company, which had a fire at a Sydney site very recently, and he made it clear that the company did not expect such an occurrence and that it was exceptional. That may be generally true, but history shows that what is expected does not always happen, and those unexpected events have often led to damage and injuries. This article will review some examples of such events, unexpected at their time, having some exceptional nature, and will suggest part of the reason why engineers in industry experience such events. Conclusions are focused on the highly responsible roles that engineers have, as what they design, can both improve and endanger lives.

Keywords: Safety, management, injuries, damage, mishaps

INTRODUCTION

This author's experience in teaching began by covering a general management subject for undergraduate engineering students. That extended into safety, the associated topic, risk, and how accidents should be prevented, but presenting that to undergraduate engineering students has proved to be difficult. These issues have been described in previous papers [1][2] going back more than twenty years, and the experience was recently extended by presenting a lecture on risk to chemical engineering students [3].

The impression gained from these experiences has been that the undergraduate-engineering-mindset person is conditioned to certainty, to an expectation that things will go on in an orderly manner, with no exceptions. To those younger people, there is no need for figurative gavels to be thumped of imaginary benches while calling for: Order! Order! because exceptions from the world-line defined by Newton's Laws and others similar do not occur, for them life goes on in an orderly manner. Where possible, the source of the examples used in this article are given, but some sources are unavailable; however, all will show expectations can be crushed by exceptions.

AN INSPIRATION

This article has been inspired by a very ordinary occurrence, which illustrates all three words in the above heading.

People are within the rights to expect a certain degree of anticipating orderly continuity from today to tomorrow, and that applies to the simple matter of using a computer to assemble a flow of words, sentences, paragraphs, expression of ideas into (eventually) print. So, when this author's anticipation of that was disturbed a few weeks ago by the computer in use behaving in a disorderly manner that was recognised as both contrary to expectations, and quite exceptional, because the device had worked flawlessly for about five and a half years. And safely?

Well, for some time this author has been vaguely thinking about the advisability of having some backup, perhaps a secondary black box or connection to one of the cloud systems, always finishing those thoughts with: *Oh*, *yes*, *well*, *tomorrow*. *Manana*. But tomorrow is busy with continuing work in progress plus new actions and activities, so more postponement occurs, and so on, and on.

Knowledge of what can happen, of what is said to have happened to others, means the computer's breakdown must have been expected, though the expectation was pushed down under the blankets. What happened differed from the day-to-day experience and was, therefore, exceptional from that.

Returning now to student's lack of accepting safety teaching, including accident narrations to illustrate the result of poor safety management, the observed attitude seems to be something like: *Oh, yeah, these accidents happen, but we don't* expect *them, they're* exceptions *to what generally happens*. Then, from the viewpoint of someone who might in the future be not involved in an accident but who might have some responsibility for its occurrence and results: *It can't happen to me*.

One of the aphorisms from Trevor Kletz, the English safety guru is: *We can't know what we don't know* [4]; in the present context one can submit: *We can't expect the unexpected*.

One will have a look at some history to dispel those ideas and see what lessons one can take from these incidents.

THE EXPLOSION IN THE PETROL TANK

Beginning with an example from recent time (reported in the Sydney Morning Herald, 27-28 July, 2013), last year a property in a northern Sydney suburb changed ownership and the new owner decided to remove an underground petrol tank used by the business, which had previously occupied the address. In preparation, liquid was emptied from the tank but the residual vapour was not flushed out.

It is reasonable to assume the men on the job had experience in doing this class of work and, therefore, would not bring any source of ignition near the tank. There would be no cigarette smoking, no matches, no welding in close proximity. *Therefore*, one would *expect* a fire or explosion would not occur.

But it did, so there must have been a source of ignition. Perhaps, a steel tool struck something and caused a spark? Close enough to the tank vapour to ignite the gas-air mixture. The possibility of this happening would have been well recognised by the workers and their managers. How come this exceptional event occurred? Probably, because preparation for the work was not adequate, the tank should have been completely cleared or sealed so that vapour could not escape.

The lesson: simply that working where there is the opportunity for an extreme event, such as fire or explosion, requires very thorough preparation.

THE OPEN MANHOLE

The author will now go back a few decades to what happened in Sydney factory which employed two electricians. The senior, leading hand, had been with the firm for many years, and had some work-practices, which worried the newly-appointed chief engineer. The way the factory's electrical system had been jig-sawed together did not appeal to his new manager, and of those practices the most worrying was the man's way of working on live switchboards while standing on a relatively thin rubber mat.

In addition, there was a management problem, the man was effectively befriended by senior people and was, therefore, a member of protected species. Also, there was common knowledge he owned residential property in the area and spent a considerable part of his unemployed time working on the houses he rented.

During an end-of-year shutdown, the cover was lifted from a manhole in an internal road. The contractor who was to work under the road quite correctly placed a portable folding barrier around the manhole. To do the planned work under the road he opened the gate in the barrier, entered it and went down the manhole.

The electricians were working on cables above that roadway and the senior was standing a couple of metres from the manhole, looking upward at the overhead work. He stepped back to get a better view, went through the open gate in the barrier and fell into the open manhole. He was not seriously injured, required some medical attention and was off work for a couple of weeks. Unexpected? Exceptional? Yes, to both. This accident can be said to be due to a series of coincidences: the manhole was open, the gate was left open, the electrician was working in the same area and was facing the *wrong* way, and when he stepped back he just happened to line up with the open gate. His after-hours working on properties, with inadequate rest, may also have been a factor in the accident.

However, one would expect the open manhole could cause an accident, so the barrier was placed around it. But the gate was left open. No-one would expect anyone would walk backwards into it; what happened was exceptional. The lesson is that safety can be negated by a relatively minor omission from safe practice, which requires all details to be rigorously applied.

THE FLYING CRANE HOOK

This example goes back even further than the above, to the 1950s, resulted in a fatality and has left such a strong impression in this author's mind that he used it, with some modifications, in a recent novel. It occurred in a Sydney chemical factory, which used steam for processing and had a problem caused by varying consumption rates. Rather than install an extra boiler, the decision was to install a steam accumulator, a large vessel full of pressurised hot water, which would store steam as pressurised water when less steam was being used and emit steam when demand increased, allowing the existing boilers to run at a reasonably constant rate.

The vessel obtained for this service was quite large (memory gives at least 1.8 metres diameter and five or six metres long) and logically needed to be located near the existing two boiler houses, so a space between the two buildings was selected and surface-cleared. Then, when excavation for the vessel's foundation was begun a large block of old concrete was discovered, obstructing the new location.

A rigger working on the project had a crane on site, and looking at this partly-exposed mass of concrete, decided the crane could pull it out, possibly encouraged by seeing protruding from it a length of steel into which a hole could be burned to accommodate the crane hook. However, access to the area was difficult, the crane was unable to get close to the block and when the hook engaged the hole in the block the crane ropes were about thirty degrees from the horizontal. Under direction from the rigger the crane driver attempted to pull out the clock.

What was reported within the company (perhaps via office-gossip?) was that the crane hook straightened and came loose, which seems rather unlikely; perhaps, the hook slipped out of the hole in the steel embedded in the block, but the result was the crane hook and the pulley on the end of the ropes was flung back by the tension in the ropes, and struck the rigger in his chest. He was taken to hospital but died in three days.

The young civil engineer who was supervising the job was not present when that happened, he had been there during the earlier part of the day but had gone to other work-areas or the office. Applying second-guessing now, one may assume that if he had been there he would not have allowed the action to have occurred, because *it just didn't look right*.

The lesson from this tragic event is the overall supervisor must keep in touch with what is going on, impressing on the on-the-job supervisor, foreman, leading hand or whoever it might be, to refer back when difficulties come up, and to mentally reason ahead to when to make the next visit to the job-site.

As an example of that, this author recalls a maintenance foreman who seemed to have that ability; he would settle down in the foremen's office, churn over necessary paperwork for a while, then, suddenly for no apparent reason rise, pick up his hard hat and safety glasses, and go out to check what was being done in the work-area for which he was responsible for no reason other than he thought it was time to actually eyeball what was being done.

One may expect workers, people generally, to act as their supervisors expect (deliberate tautology) but when exceptional, puzzling, circumstances arise they may head off in unexpected directions.

WHEN THE RULE DOES NOT APPLY

Moving back even further to the late 1940s, there is an example (from this author) of a rule, which existed but was not applicable at the time and place where the accident occurred.

It was a time when Victorian drivers wishing to make a right turn were required or allowed, to remain in the left lane until both traffic on their side of the road and on the other side cleared; contrawise, New South Wales drivers were required to wait near the road-centre for a right turn. On this occasion, a Victorian driver of a prime-mover was waiting on the left side of a four-lane road in Sydney, still moving very slowly, ready to turn, and a motor cyclist came up behind his vehicle.

The prime-mover driver, sitting higher above road level, did not see the motor cycle lower down, thought the traffic behind him had cleared, and began the right turn just as the motor cyclist started to go past. The rider saw the front wheel starting to turn, accelerated to get clear, but his left leg was caught by the vehicle's front fender and was broken. It was subsequently repaired to working level, allowing easy walking but no freedom of running. Although there were several factors in the incident the root cause was simply that the Victorian driver was following a rule not applicable in this state.

This incident is included here as a dramatic illustration of the importance of abiding by whatever rules (or regulations) may apply in any particular geographical area, applicable more today than at the time. The above occurred because the locally applicable rule was not followed. Today, people now have more globalised business, with engineering goods and services flowing in from other countries. But other countries have different standards, which means when an engineer is involved in an importing situation he/she must make sure the item meets the required standards, rules and regulations, whatever is applicable. The possible consequences range through being unable to use the imported item to use after modifications to

financial loss. And, the same applies to goods and services exported to other countries, when it must be ensured that their required standards are met.

ENTRY TO AND EXIT FROM A CONFINED SPACE

Here is another fatality case. This author must admit to having worked in several firms where workers have been killed, and from many viewpoints, it is somewhat bizarre. It occurred during a night shift, in a factory with several batch-processing reactor vessels, which sometimes had to be entered to clean them when there was a product change. On this occasion the process operator in the particular factory area decided to prepare the particular reactor for the next product batch, so he entered via the manhole and cleaned the interior.

First error: he did not call for the night shift supervisor or another operator to stand by while he was in the reactor, even though he knew that entry into a confined space requires another, outside.

Then, he used some help to exit through the manhole. Entry through an 18-inch diameter manhole is difficult, but getting out is even harder when there is no-one to help, but there was an air-powered hoist on a monorail above the reactor, so he had prepared to use it by running the hoist chain down before he had entered. He now ran the chain down into the reactor, wound it around his chest, clipped the hook into a link, and pulled the *UP* hoist toggle.

Second error: using a powered device on the human body.

He became stuck at the manhole, the hoist kept running, the chain became tighter, crushing his chest and preventing his breathing, he passed out, and when found later by the shift supervisor was quite dead.

It was not possible, of course, to ask the operator why he used the hoist as he did, but the opinion of all the employees, and outsiders, was that no-one in his right mind would do such a thing; it was totally unexpected and exceptional, and the lesson from that incident is that people must be informed to the extent of being brainwashed that certain rules must be followed, such as do not enter a confined space without a standby person, and do not use machinery on the human body.

THE PACKAGING LINE

Machine accidents and injuries are, unfortunately, common, and a notable one occurred in a Sydney factory about fifteen years ago (reported to this author by one of his students), in a long tunnel-like machine, which produced and packaged an item used domestically, fed at one end by product materials, then, progressively forming, wrapping and, finally, spitting out bundles to go to supermarkets and other retail outlets.

As one might expect, such a complex automatically controlled operation required internal work on it from time to time, so the machine was built with a series of doors for inspection and adjustment, all fitted with micro-switches to isolate the drive if a door was opened. But, during one shift, a fitter opened a door to make adjustments, gimmicked the micro-switch to the closed position, so the machine would run while he worked, presumably so, he could see the results of the adjustments he was making. He must have misjudged where he could reach and put his fingers into a running toothed belt drive.

And, looking back at the heading words, the designers *expected* work would have to be done on the machine, but not while it was running, so a safety feature was installed, but they did not allow for it to be defeated by an *exceptional* action. Design for safety is not an easy task as elaborated on by the author in his earlier publication [5]. This leads to the macabre joke often made about such situations that designers can be very clever making machines safe, but there is always some even more clever idiot who can find a way around the safety provisions. The lesson from this incident is that guards and other protective devices are all very good, but they can be defeated. After that accident, which resulted in a disabling injury, the micro-switches were replaced with a light beam across each doorway.

A SUGGESTED CAUSE OF SOME EVENTS

This returns to a point made in an earlier paragraph that undergraduate engineering students may accept the concept of safety, but do not accept that unsafe conditions exist and can lead to damage and/or injuries. Of course, those juniors do grow up and their attitudes change, but observation and thought suggest that earlier attitude is, in many engineers, replaced by confidence in *the system*, which prevents a potential hazard (another deliberate tautology, a hazard is in itself only a potential) causing damage or injury. Just as the presence of the micro-switches in the above machine prevented entry while the machine was running.

During the Hazop meetings (late 1970s) which examined safety in an LPG tanker-loading depot someone asked: *What about a driver starting off with the filling hose still connected?* One member of the committee vehemently protested: *That can't happen*, and he pointed out feature after feature in the design, all there to prevent a major gas spill caused by driver-error. Another member produced information showing that it had happened, even with all the safety features. The

protestor's confidence in *the system* was overcome by others who preferred to believe it could happen, and extra hardware, plus tight procedures, had to be present to prevent such a spill.

So, summing up this point, engineers need to realise their actions (or non-actions) can lead to exceptional happenings. Even though some engineers have enough imagination to picture what might be expected to happen. The well-famed Willy Hammer has pointed out engineers and their actions have been, and can be, causes of accidents [6]. Rarely, perhaps, indeed probably rarely, but it can happen. Confidence can be mis-directed. Having confidence is all very good, but sometimes one should have doubts in parallel.

AN EXCPETION TO ALL THE ABOVE ARGUMENT

Much of the argument presented above centres on the idea that everyone should do what is right and proper, follow the rules, play the game as it should be, do not act in exceptional ways.

Having said all that it is now necessary to partially reverse that with a codicil. Sometimes, though rarely, yes, very, very infrequently, there is a need to act contrary to expectation, in an exceptional manner; it is when the person seeing what is going to happen has brief, limited, time and opportunity to act so that the untoward event does not occur. If the action is successful, management usually has a duplex task: in one breath the person who acted has to be severely reprimanded for not doing what *the book* says; then, in the next breath must thank the same person for preventing possibility becoming reality.

Reflecting on management's position in such a situation suggests it is highly likely that earlier and correct action by management would have prevented the situation from arising.

CONCLUSIONS

Sadly, the recent experience with a class of students leaves this author with the continued belief, indeed conviction, that up-and-coming professional engineers do not appreciate the vital nature of industrial safety and there is some evidence experienced engineers have the same lack. Should all engineering faculties employ a lecturer named Murphy so that his law can be taught with Newton's?

Here are two possible scenarios. Perhaps, this author has been sensitised by working where fatalities have occurred and by working as an accident investigator and expert witness? Perhaps, the average (dangerous word) student will go through professional life never having a fellow-employee killed or experiencing a serious accident?

Both are possible. Even if both are true, all engineers need to understand that what they design and build can injure and kill people.

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BIOGRAPHY

Ronald Bentley Ward arrived in Sydney, New South Wales, on 6th October 1928. He attended early schools in inner suburbs, then, Sydney Technical High School, still recognised as the one for engineers and scientists, which was in the 1940s located close to the city, now in a southern suburb. After passing the Leaving Certificate in 1945, he worked as an apprentice, then, as a tradesman toolmaker at the Commonwealth Aircraft Corporation from 1946 to 1954. He, then, moved from aircraft engine manufacture to chemicals and worked with several firms in engineering positions up to 1979 when he opened his own consulting firm, specialising in project management. In 1984, he became a lecturer at the New South Wales Institute of Technology, which became the University of Technology, Sydney, and retired from that position in 2001. While working in industry, he completed a trades course in fitting and machining, the Associateship Diploma (Mechanical Engineering) of the Sydney Technical College, Bachelor of Engineering at the University of New South Wales, and Master of Business Administration at Macquarie University. During the years at the University of Technology he returned to the

University of New South Wales to research a thesis on the relationship between hazards and management practices in the chemical industry and was awarded the degree of Doctor of Philosophy in 1995. He has published three books, one text on communication, another on engineering management and a third book outlining some engineering oddities, plus well over a hundred-and-forty papers on education, engineering, accidents, management and speculative topics, over a hundred-and-twenty expert witness reports. He has also written a series of one hundred-and-ten fictional case studies and two novels, one yet to be published. All of these exemplify his interest in engineering as a profession and the need of a broad education at the undergraduate level, where topics other than those purely technological should be included and presented in a manner to suit those students. He has lived in Sydney suburbs all his life, and travelled interstate and overseas many times to conferences with his wife, Brenda. He has maintained his connection with engineering education by continuing to write and publish, and by having been accepted in 1998 as a Visiting Fellow in the Faculty of Engineering of the University of New South Wales. He thanks WIETE for the invitation to submit this article for the Global Journal of Engineering Education.