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The management of accidents

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ABSTRACT

Purpose: This author's experiences in investigating well over a hundred accident occurrences has led to questioning how such events can be managed - - - while immediately recognising that the idea of managing accidents is an oxymoron, we don't want to manage them, we don't want not to manage them, what we desire is not to have to manage not-them, that is, manage matters so they don't happen and then we don't have to manage the consequences.

Design/methodology/approach: The research will begin by defining some common classes of accidents in manufacturing industry, with examples taken from cases investigated, and by working backwards (too late, of course) show how those involved could have managed these sample events so they didn't happen, finishing with the question whether any of that can be applied to other situations.

Findings: As shown that the management actions needed to prevent accidents are control of design and application of technology, and control and integration of people.

Research limitations/implications: This paper has shown in some of the examples provided, management actions have been know to lead to accidents being committed by others, lower in the organization.

Originality/value: Today's management activities involve, generally, the use of technology in many forms, varying from simple tools (such as knives) to the use of heavy equipment, electric power, and explosives. Against these we commit, in control of those items, the comparatively frail human mind and body, which, again generally, does succeed in controlling these resources, with (another generality) by appropriate management. However, sometimes the control slips and an accident occurs.

Keywords: Accidents; Causes; Results; Management

1. Introduction

This paper will begin by defining some common classes of accidents in manufacturing industry, with examples taken from cases investigated, and by working backwards (too late, of course) show how those involved could have managed these sample events so they didn't happen, finishing with the question whether any of that can be applied to other situations.

2. Definitions and an illustration

To know what's being discussed we begin with defining: what is an accident? Kletz [1] has stated: "An accident is often defined as something that happens by chance and is beyond control," and added he disagreed with the principle in that because in his opinion most accidents are both predictable and preventable He gave a further definition, which he prefers, from [2] "An undesired event that results in harm to people, damage to property or loss to process," which focuses on results without suggesting causes.

Many years earlier [3] quoted Lord MacNaughton who, in Fenton v. Thorley & Co. Ltd. (1903), defined an accident as "some concrete happening which intervenes or intrudes itself upon the normal course of employment. It has the everyday meaning of an unlooked-for mishap or an untoward event, which is not expected or designed by the victim". A somewhat longwinded definition, what might be expected from a senior judge, and fairly effective, but as pointed out by Bamber in the reference cited only covers injuries to people, not damage to property.

Another definition, rather lengthier, comes from [5]: “An accident is usually a dynamic event since it results from the activation of a hazard and culminates in a flow of sequential and concurrent events until the system is out of control and a loss is produced,” with the addition of: “ - - - an accident is an undesired and unplanned event that results in death, injury, or property damage,” essentially agreeing with [1].

Many other references, as old and more recent, cover the same ground. As an illustration of all the above factors we have the “pedestrian and banana-skin model” [6] in which we visualise a banana skin dropped on the footpath.

The first pedestrian sees the banana-skin and avoids it (to him the possible accident is predictable and preventable), the second treads on it, skids and recovers (what is termed “a near miss”), the third treads on it slips, drops and breaks a bottle of wine (property damage) but isn't injured, the fourth slips and is hurt (injury, but minor), and the fifth falls heavily and is seriously injured (serious harm to a person). The third, fourth and fifth show “activation of a hazard” and “a flow of sequential and concurrent events.”

We may also consider a possible sixth case, the pedestrian who doesn't see the banana-skin and walks by without stepping on it, which illustrates there is a difference between consciously avoiding a hazard (the first pedestrian) and inadvertently, or involuntarily, or unintentionally, avoiding a hazard (the sixth pedestrian). The observation that latter case can exist leads to question the influence of what one can only call "blind luck" - or is it, perhaps, the notion of Kismet, that a person's fate is written on his forehead? - - - more of which, later.

3. The initiating factor

What must be present to provide opportunity for an accident to occur? This necessary factor is a hazard, something which in itself presents no danger but when “activated” (to use the word in the Roland and Moriarty definition) leads to damage or injuries, or both. The banana skin in the King and Magid illustration is a good example of a hazard; its presence on the footpath is quite innocuous, but when a pedestrian steps on it the result may be dynamic (the pedestrian staggers and flails arms around) and out of control (then loses balance and falls).

A hazard presents no more than a potential for accident, it’s a sleeping dragon, only dangerous if wakened.

4. A taxonomy of accidents

Any attempt (including this one) to divide accidents into classes becomes mired in the number and variations which have been recorded.

As a starting point, we can separate Major Accidents from Minor Accidents. Then, within those categories, we can distinguish Results from Causes. The reasoning for that is supported by Bamber’s examination [3] of forty accident definitions, which led to his suggesting that “the ideal accident definition should have two distinct sections: a description of the causes, and a description of the effects.”

5. Major accidents

There seems to be no distinct quantification of what makes an accident “major”. Like beauty, that quality “major” may be in the eye of the beholder, depending on one’s view of what has happened.

Alternative terms for major accident are “catastrophe” and “disaster”, and Lancaster [6] goes further with the term “supercatastrophes”. He provides something of a definition for “major” (referring to a previous chapter in his book):“- - - a catastrophe was taken to be the loss of any substantial human artifact such as a ship, an aircraft or a unit of process plant. In most instances a minimum size limit was set: 100 tons displacement for ships and 60,000 lbs weight for aircraft. In the case of process plants the largest dollar losses were recorded, such that the minimum loss was in the region of US $10 million.”

Shipping accidents can certainly come into the major class, with the Titanic leading the field. So do aircraft accidents; the failure of the DH Comet, going back some forty years, was certainly major.

If we consider the chemical industry, as a source of industrial accidents, there have been major accidents involving fire, explosion and toxic releases, twenty-seven of which have been briefly detailed by [8], and these, although not defined by the writers as “major” must certainly be in that class. It’s easy, in that industry, to exceed the $US10 million minimum loss mentioned above by Lancaster.

But selection of which term to apply to a particular case depends on the point of view. Consider one that this author investigated several years ago, one in which a small factory producing plastic packaging chips was destroyed by fire, caused, we believe, by electrostatic ignition of the product. Unfortunately (for the small factory’s owner), another part of the building occupied by the factory was used as a store by a large airline firm, which sued the small company to the tune of some three million dollars, so from their viewpoint (loss of their plant and a substantial damages bill) the event was definitely major. However, for the airline what happened was probably a minor matter, a nuisance caused by loss of stock availability, and the value loss to them was probably in the petty cash region. And, if we were to compare the above claim by the airline with Lancaster’s minimum loss figure, to judge whether it was major or minor, we’d have to class it as “minor”.

Perhaps the only feature of this distinction agreed in the literature is that major accidents, with very large loss, occur relatively seldom, although the macabre opinion has been expressed thet there’s now enough oil refineries in the world, and enough fires per year, to have one refinery burning merrily every day. An exaggeration, one hopes.

6. Minor accidents

These are relatively frequent, unlike major accidents. They are, usually, events causing injuries to workers, such as cuts, bruises, sprains and the like, generally recoverable. But, again, any attempt to classify these is flawed by the difference between the perception of the person injured and that of an external observer, for what may be seen as minor by the latter may be considered to be at least serious by the former.

To illustrate that, take what happened to a contractor who was installing an air conditioner in the window of a room in a warehouse building [9]. The contractor asked for help to lift the unit into place, and a forklift driver working obliged by lifting the airconditioner unit. The driver and the contractor were concentrating their vision on the window at which they were aiming the unit, with the contractor standing on one of the tines (well known as a bad practice) and holding onto the top rail of the guard which prevents loads from falling back onto the driver. All was going well until the driver raised the load the last few inches and the fitter's hand was crushed between the fork's guard rail and the concrete ceiling. The injury was not totally disabling, but he lost two fingers which interfered with his guitar playing, which was serious, hence major, to him.

Minor accidents relate also to property damage. As an illustration, a fertiliser store building (in this author's maintenance domain, years ago) had a concrete block wall damaged by forklifts using the wall as a buffer, when placing pallet-loads of sacks near the wall, actually, of course, against the wall. Bit by bit the block's mortar joints were broken and the wall shifted outwards. It didn't fail and fall into the railway siding behind it, and was never repaired, so no cost was involved, therefore: can it be classed as a "minor property damage" example? It's even harder to class it as "an accident".

7. Results

Examples of results have been provided in the above sections, briefly summed up here.

Major accidents can result in high-cost property damage (even total destruction of property) or human injuries including fatalities, or both.

Minor accidents may cause relatively small damage to property and relatively minor injuries (with the above questioning of applying "minor" to people injuries), or both.

8. Causes

This is where the taxonomy-development becomes interesting. Judging by cases investigated, causes can be broadly divided into "technology faults" or "human faults", or a combination.

Technology faults may be due to equipment failing in service, caused by overload, which in turn may be due to a process error, but even if operating standards are correctly followed a technology failure can be due to the latent presence of a designed-in weakness which will come out when a trigger event occurs. The very real worry with technology is its unforgiving nature, once that trigger is tripped there is usually no going back, we can't rewind the sequence and start again.

As an illustration, consider "the pumpkin soup case", a seemingly elementary, indeed homely, investigated case providing an example which covers many aspects of technology faults, also an example of asking, and answering, the right questions by performing experiments. The injured person was a young woman who had a blender, given to her by her sister as a wedding present, and when using it for the first time to prepare pumpkin soup the lid blew off and splashed her with hot liquid. The provided photographs showed serious scald injuries along her arm and across her body front. She sued the manufacturer.

This was one occasion when the vital piece of evidence was available: the lawyer had the blender and handed it over for inspection. We (this author and wife) made pumpkin soup, following the same recipe and procedure, poured it into the blender, not exceeding the recommended level, and the switch was flicked very briefly. The lid was held down firmly, but in the one or two seconds of running the lid lifted and hot liquid spurted out from under the lid. Repeated tests under different conditions, different levels and temperatures, confirmed this was indeed a physically hazardous process!

The manufacturer's instructions were reviewed; they did not warn this could happen. Fourteen other brands of blender were inspected and reviewed, most had only fairly tight labyrinth seals, some had loose lids, and some had lock-down lids which might leak but wouldn't spray as the one tested did. The suggested conclusion was that the manufacturer had been negligent in not advising users to hold the lid down, not to blend hot liquids, and not to fill above a certain safe level. Sadly, we were not informed what compensation was made by the blender manufacturer.

Looking at what happened, and the experiments, from a process-engineering viewpoint, there's an uneasy feeling that there may have been some incompatibility between the recipe and the type of mixer being used, that is, a process error. However, the equipment did fail in service, probably due to some containment overload, which compounded with what appeared to be a design weakness, even though operating instructions were followed. There have been similar cases in industry, usually harder to examine as this one was.

Human faults can include the designing-in of weakness allowing a technology failure to occur. More often, the human fault is a mistake, doing something wrong, by the commission of an error, which may involve not only one person but several.

Many writers (for example, [10] early in this category) present accident causation beginning with organisational processes, leading to error-producing conditions, which lead to unsafe acts. There should be defenses to prevent those acts leading to accidents, but loopholes may exist in those defenses, allowing accidents to occur. Such a sequence can follow an organisation allowing a worker to serve a second shift after his normal finishing time, leading to a tired person being prone to error, leading to an unsafe act such as ignoring a process departure from correct conditions, but the alternative, running a process with the shift numbers one-down could be offering opportunity for the same possible events to occur.

Once again, we offer a seemingly simple example [9]. A 9,000 litre batch of organic chemical was being processed in a heated reactor, and at the end of the usual eight hours the reaction had not progressed, the ingredients were still only a mixture, not the expected compound. More catalyst was added. Chemists conferred. The most senior technical person in the firm attended and puzzled over it, as the batch went on overnight and into the next day. Finally, the answer clicked in someone's mind, oxalic acid (code A7) had been sent from the store and was being added as catalyst, instead of sulfuric acid (code A1). This happened because the batch sheet had been written by a person of European extraction who gave the "1" a heavy top stroke, which the Australian person loading the pallet in the store read as a "7".

Later, in the investigation, the writer said if he'd meant "seven" he'd have put a stroke across the vertical line of the number, but he knew it was a "one", so he was satisfied, just as the Australian reader was sure it was a "seven". Finally, sulfuric acid was added and the reaction zoomed ahead as it should have, earlier. The only losses were production capacity and fuel oil.

Looking back at the number of people involved, there was the form-writer, the form-reader-storeman, the plant operators on three shifts, several chemists, the Technical Director, and maintenance personnel including this author, all trying to solve a problem which didn't exist, caused by a writing error? And a reading error? (Depending on whose view we take?)

As an example of technology fault combined with human fault we return to the case of the wall broken by forklifts stacking pallets of fertiliser. The technology was at fault by the forklifts being able to reach the wall instead of being stopped by a barrier, or by having some proximity-sensing device. The human fault was the behaviour adopted by the drivers, who, in trying to maximize aisle space, kept touching the wall, but a mere "touch" by more than two tonnes of vehicle and load made quite an impact.

9. Management

So, to management, defined a century ago, more or less, by Fayol as the combination of four actions: planning, organising, leading, and controlling, with some variations which depend on the taste of the particular writer. Fayol's definition has been quoted with minor modifications by many others, for example, by [12]: "To manage is to forecast and plan, to organise, to command, to co-ordinate and to control. To foresee and provide means ok examining the future and drawing up the plan of action. To organise means building up the dual structure, material and human, of the undertaking. To command means maintaining activity among the personnel. To co-ordinate means binding together, unifying and harmonising all activity and effort. To control means seeing that everything occurs in conformity with established rule and expressed command.

From that, summarising Fayol's statement, the tasks of management are planning, organising, commanding, co-ordinating, and controlling. Allen pointed out that Fayol's use of the word 'command' did not fit into post-World War 2 society and substituted 'motivation' for 'command', and with subsequent writers reduced Fayol's multiple management functions to four: planning, organising, motivating (or leading), and controlling. These four classic functions of management are iterative and inter-related by decision-making, a central task

Drucker [11] reduced the above to only three tasks, expressed more broadly: the specific purpose and mission of the institution, whether business enterprise, hospital, or university; making work productive and the worker achieving; and managing social impacts and social responsibilities.

How does that fit with accidents? The answer, simply, is that it doesn't. Or does it? Consider planning. No company director would admit to planning to have accidents, but there is, generally, an expectation that during a year of operations a certain number of accidents, some with injuries or worse, some with property damage, will occur. Indeed, several years ago an engineer who worked for an electricity generating organisation was heard to say six fatalities were anticipated ("planned?") every time a power station was built. Not, of course, due to management action, not even due to management inaction, but because "these things happen".

Having stated that, now we ask: is that entirely true? Surely management does nothing to cause accidents? Well, there have been examples quite contrary to that, occasions when management directly contributed to an accident, with Chernobyl being to most outstanding, for that event was directly related to management deciding to run an operational test which was inherently unsafe [13]. More recently, in Australia we've had the fire at Longford, the Esso gas plant in Victoria, which was apparently initiated by an operational error supported by the supervisor level of management [14].

Once again a small-scale example is available, here to illustrate management's culpability in an accident.

A paint store in a Sydney prison contained a collection of solvent-thinned paints and some solvents, in containers varying from 0.8 litres to 20 litres. There was an allegation that a prisoner had forced open the door, splashed himself with solvent, and ignited it. That incident was believed to have damaged the paint store door, which had been forced, with one hinge broken away from the door, so the management issued instructions via the chain of command to a warder that the door was to be repaired. The warder located two prisoners with welding experience and ordered them to perform the repair, so arc welding equipment was brought to the room. The only safety precaution taken was to have a fire extinguisher close by.

The prisoners remarked that they could smell solvents, pointed to spills they could see on the floor, complained that what was proposed was dangerous, and objected to doing the work. They were told to get on with the job, so they swung the door to a partly open position, and the one more experienced in welding used the welder to strike an arc to tack the hinge back on the door. Then they swung the door back and forth to test alignment and the tack broke. So they set the work up again and struck a second arc, to re-tack the hinge in place.

This time the store exploded in a typical vapour cloud explosion, with a flame wave coming out through the doorway.

Ironically, the two prisoners were somewhat sheltered by the door because they were working on the outside of it, so they were only slightly injured. But the warder was standing in line with the door opening and was hit by the flame as it exploded out of the room, his clothes ignited, and he was burned over a over a large percentage of his body, hence hospitalised for a long period. Management, via the "chain of command", was obviously involved and could be said to be responsible.

The significant word in Fayol's celebrated statement is "control". In order to prevent accidents happening, or to minimise the results if they do happen, management must control what goes on in the managed organisation. Reducing the elements of control to a basic minimum, perhaps to the level of reductio ad absurdum, means ensuring technology faults do not occur, and neither do human faults, raising the question: how may we, managers, do that?

10. And beyond fayol?

The explanation given by Newton, to explain why he might have been able to see further than others ("I have stood on the shoulders of giants", referring to those whose work his followed) has always impressed this present author, and now, introducing an extension of the four management tasks the same applies here - - - without Fayol (and the other giants after him) as a starting point this thought would not have been generated.

Some years ago, when teaching management to undergraduate engineers this author added "innovating" to the four tasks, but another has come from the combination of this paper and the research performed in the 1990 period: it's integrating.

Going back to the research, which was on hazards and management practices [9], both the investigation and industrial experience supported that a chemical production operating unit can be described in the following manner:

- the physical equipment is the concern of mechanical engineers,
- the materials are the concern of chemists,
- the processes are the concern of chemical engineers,
- the workers are the concern of human resource staff,
- the management is concerned with itself and management scientists-consultants,

that is, each discipline is commonly compartmentised in and by its specialty. No-one is an overall expert, which would be too much to expect, but management should provide an integrating action to bring together the thinking of all those specialists. Such integration was observed in neither industrial experience nor in the research investigation.

Now, while that was only from one particular industry, one may reasonably extend the concept to others. For example, a similar research into our state rail organisation would probably find the same sort of compartmented interests, which may well be a contributing factor to the problems that organisation has been having through recent times.

11. Do accidents "just happen"?

There is a common feeling among many, including managers who should know better, that accidents "just happen" and we have to put up with them and their consequences. Agreement with [1], that most accidents are both predictable and preventable, is hesitant, reserved, indeed, likely to be insincere even if expressed. For accidents do happen. How can they be managed so they don't happen?

Working now backwards through the above development, taking human faults first (because they seem to be the most difficult to overcome) the only suggestion which can be given here is an industrial organisation should think ahead, as a community, before acting. Such a simple concept, but it's one which could eliminate many undesirable consequences by shorting out what leads up to them. The old carpenter's adage could well be applied: measure twice, cut once to many human activities.

Preventing the introduction of technology faults is (in principle) much easier (although usually more expensive) that preventing human error faults. It depends on developing the concept of inherent safety, a line of thought which seemed to come forward ten-to-fifteen years ago. In one industry it depends on three factors: the magnitude of available physical and chemical energies, the maximum effect radius if these energies are accidentally released, and the maximum expected losses following such a release [15]. Although those particular factors relate specifically to that one industry similar factors can be set forth and stated for other industries.

Here, management is deeply involved. We, in the Warringah Shire in Sydney, have recently found a manufacturing firm to be emitting a carcinogenic gas from its premises. Investigation (by the local press) found the company's management was well aware of what was going on, and the decision to do nothing, to allow the release to continue, was based on the cost of installing equipment to filter out the gas.

12. A review

It's time to review the accidents described in the above sections, with a note whether each could have been prevented.

The "banana skin" is, of course, fictitious speculation (or is it speculative fiction?) and serves, mainly, to show how a hazard does not necessarily cause an accident. The fire in the plastic chips factory is an example of how a latent error, omission of earthing, can lie in wait for some time, then cause an accident (preventable by earthing the ductwork). The contractor's hand was crushed because the two people were concentrating on one feature of what was being done, not on the overall situation (preventable by employing overall, "spherical", vision).

The block wall in the fertiliser store was damaged by a mixture of human action and use of heavy, energetic, equipment (preventable by better human judgement). The "pumpkin soup" case was, probably, the result of a device being designed with inadequate thought for what it might be used (better design required).

The slow-reacting chemical batch was a pure human error case, in which everyone knew what they themselves meant and knew, starting from what one person had done (symbols should be standardised). And the fire in the paint store was due purely to management (consequences must be considered before actions).

All so simple, in hindsight. Why was there no foresight?

13. Conclusions

Harking back now to what was expressed in the abstract, accidents should be managed so they do not happen, but as shown in some of the examples provided, management actions have been know to lead to accidents being committed by others, lower in the organisation. The management actions needed to prevent accidents are control of design and application of technology, and control and integration of people.

Acknowledgements

No reference has been given for some of the accidents used as illustrations. Those were cases investigated by this author for law firms, some acting for the plaintiff, some for the defence, and details such as names and places have been omitted for legal reasons.

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