LEARNING LESSONS FROM INCIDENTS: A PARADIGM SHIFT IS OVERDUE

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Drawing on historical data we show that the international community of process engineers has not been good at learning lessons from their past accidents. We call for a paradigm change in the way we approach this and the creation of a single new, multi-national, multilingual accident database that includes lessons learned. It must be user-friendly and free at the point of use. The purpose of this paper is to challenge those in authority, and with the power to do so, to make this happen. We give some preliminary views on what may be required. This could include an element of compulsion.

KEYWORDS: Acccidents, incidents, lessons, learning, comprehensive database, multi-lingual, free access

INTRODUCTION

Whenever there is a catastrophe we are always told that 'lessons will be learned': this phrase has become such a ubiquitous element in our everyday experience and vocabulary that we just seem to accept that it will happen. It is used by spokespeople following "natural" disasters such as an earthquake or tsunami, or man-made incidents derived, for instance, from financial, political, military or engineering activities. But unfortunately, for example, lessons from the actions of the rogue trader Nick Leeson (whose loss of £827 million in 1995 brought down Barings Bank) didn't prevent subsequent similar, and even larger, rogue trader losses at the Sumitomo Corporation, Société Générale or UBS. In an analogous manner, and as an international community, we too have failed to learn lessons sufficiently well from past experiences. By looking at some very different types of incident within the process industries we demonstrate that as an international group of professional engineers we are nowhere near as good as we should be at 'learning lessons' from the incidents that have been associated with our activities. The choice is ours: we can continue to muddle on as we are doing or we can recognise these failures and try to address them with a different, concerted plan of action.

Because modern communications are so fast it should have become much easier than previously to disseminate lessons learned within a company (even if it has sites on different continents), amongst professional groups or within the process industries as a whole. But this is not happening nearly as well as it should do, not least because we are all inundated with information. Many years of describing incidents, accidents and their investigations at conferences, in journals, in government reports, in books or encyclopaedias have been shown, as best, to be only partially effective – even if well meaning. We will argue that a paradigm shift is now required in the manner that we use to try to ensure that lessons are learned. We propose that this needs to include the creation of a single, comprehensive, international, accident and incident database: obviously this will need to user friendly, include lessons learned, be available in a variety of languages and be searchable using a flexible methodology.

OUR PROFESSIONAL RESPONSIBILITIES

Most of the professional bodies to which we belong make very strong statements about the responsibilities and duties of their members in relation to health and safety. For instance the first cannon of the Code of Ethics of the AIChE states unambiguously that members will "Hold paramount the safety, health and welfare of the public and protect the environment in performance of their professional duties", see http://www.aiche.org/about/code.aspx. The word 'paramount', of course, means 'supreme', 'most important', or 'above all others'. Disappointingly, "safety" makes no explicit appearance in the four "Key Aims" of the IChemE's mission statement which chooses instead to talk of "excellence", "relevance" and "esteem".

Most, or many, of us would subscribe, at least in public, to the principle of holding the safety, health and welfare of the public paramount. If this is so then it seems logical that every assistance should be given so that all process engineers can follow this AIChE cannon: for this reason alone we propose that the accident and incident database for which we argue must be freely available to all end users.

To write that only "most, or many, of us would subscribe, at least in public, to the principle of holding the safety, health and welfare of the public paramount" may disturb, or be offensive, to some readers. But as recently as February 2012, in an article on "UK offshore safety" published in The Chemical Engineer, Geoffrey Maitland, Professor of Energy Engineering at Imperial College London was quoted as saying "that operators on the UK continental shelf have a "patchy process" of sharing best practice *and lessons learned* from incidents as they are concerned about admitting liability and releasing intellectual property," IChemE (2012). In the light of our own professional experience and with this type of comment as corroboration

it seems as if, at least in the minds of some, financial, intellectual property or legal considerations also have a claim to being held paramount.

HISTORICAL BACKGROUND TO LEARNING LESSONS

Barton and Rogers (1997) remind us that as early as the 14th century, industrial accidents were described, with comments such as *'Don't be alarmed, help to sweep up the floor, Just as we always do, and try once more!',* (Chaucer 1386). But, as described in the next section, by 1785 we have the details from Italy of a well documented accident investigation: much later the famous sentiment "Those who cannot remember the past are condemned to repeat it" appeared in "The life of reason", Santayana (1905), and then pioneers like Ducommun in the USA and Kletz in the UK helped publicise this concept and develop methodologies and systems to improve the safety performance of the process industries in a systematic way. Our current activities include carrying out incident and accident investigations with root cause analysis and compulsory regimes of reporting. For significant events, and to publicise 'lessons learned' that may be of use and applicability to others, we arrange seminars, make presentations at conferences, write up case studies in journal articles or books, have entries in encyclopaedias and assemble databases. Company newsletters (hard copy or electronic) and intranets are used to disseminate information. However all of these activities, and over 200 years of experience, have not and do not prevent repeat accidents. We need to accept this failure, use it as feedback and then as a matter of urgency refine what we are doing, make it much more effective, make it easier and cheaper to be able to access and 'learn lessons' and, perhaps, also to introduce some legal framework for compliance.

THREE EXAMPLES OF CLASSES OF REPEATED ACCIDENTS

1. DUST EXPLOSIONS

One of the first recorded accident investigations followed an explosion at about 6.00 p.m. on 14th December 1785 in Giacomelli's flour warehouse in Turin, Morozzo (1795). Eckhoff (1991) recounts in full aspects of this well known investigation (as reported in the Memoirs of the Academy of Science of Turin). Count Morozzo correctly identified some unusual features of the flour, i.e. that it was exceptionally dry, and recounted a similar "near miss" incident at Joseph Lambert's Bakery, also in Turin. He wrote:

> *"Ignorance of the fore-mentioned circumstances and a culpable negligence of those precautions which ought to be taken, have often caused more misfortune and loss than the most contriving malice; it is therefore of great importance that these facts should be universally known, that the public utility may reap from them every possible benefit."*

Over a 30 year period between 1958 and 1988, 984 incidents of fires and explosions involving dusts and powders were reported to the UK HSE: there is also good evidence from the British Materials Handling Board that there may have been significant under-reporting. These incidents resulted in 1357 non-fatal injuries and 39 fatalities. Partial statistics over the period from 1979 to 1988 indicate that 46% of these events involved dust explosions. As a result in the UK a variety of books and guidance on how to avoid dust explosions and their consequences were prepared, e.g. Schofield (1984), Schofield and Abbott (1988), HSE (1994–2), IChemE (1993). Happily the incidence and severity of dust explosions in the UK has since fallen.

The picture has been less satisfactory in the US where independent dust explosions in 2003 at West Pharmaceutical Services, CTA Acoustics and Hayes Lemmerz Automotive Parts resulted in 14 fatalities. But what finally woke people up from their "safety slumber" was the tragic sugar dust explosion at the Imperial Sugar Refinery, Port Wentworth, Georgia, on 7th February 2008 in which there were 38 non-fatal injuries and 14 fatalities, CSB (2009–2). Some of the immediate causes were simple to identify and included poor housekeeping, large accumulations of finely powdered sugar and no system for management of change. And then the wheel turned full circle and in Atchison, Kansas in 2011 there were 6 fatalities resulting from a dust explosion within a grain storage silo. So 226 years after that first flour fines explosion in Turin the carnage continues. Happily the CSB has decided to try to be the agent for necessary changes and the early results of their endeavours are starting to bear fruit. However, it is difficult to imagine that any relatives of those killed or injured in recent dust explosions, or indeed any member of the public, would subscribe to the view that process engineers have learned well the lessons that Count Morozzo intended.

2. RUNAWAY REACTIONS

Reports of runaway reactions are ubiquitous. For example, in Europe these include descriptions of accidents at the Icmesa Chemical Company (which led to the EU Seveso Directives) (Marshall, 1980), at Holliday Dyes and Chemicals (Partington and Waldram, 2002), and at Hickson Pharmachem (HSA, 1994), Hickson and Welch (HSE, 1994–1) and Corden Pharma Ltd., (Irish Times, 2012). Typical features of runaway reactions involve an exothermic reaction, inadequate cooling, a sealed system, a rise in temperature and reaction rate, overpressure and loss of containment as a consequence of either activation of pressure relief devices or equipment rupture, possibly followed by fire.

As with dust explosions, the frequency of runaway reaction incidents (on all scales of operation) led the HSE to produce two good guidance documents, HSE (1997) and HSE (2000). The EU also funded a major project on runaway reactions, Harsnet (2002): the HarsNet website is an excellent source of free information about how to reduce and control residual risks when carrying out batch

and semi-batch exothermic processes. However, many chemical engineers still graduate without any formal exposure to such material. Nowhere has this been more true than in the USA where in 2006 the Mary Kay O'Connor Process Safety Centre (MKOPSC) at Texas A&M University carried out a survey on the teaching of process safety in US chemical engineering departments. There was a 57% return but only 11.2% of the responders had a compulsory core course in process safety in their undergraduate curriculum. It is a pity that so few people took much notice of these: if they had then lives might have been saved. Previously, in 2002, a Chemical Safety Board (CSB) survey had identified 167 serious reactive chemical accidents that occurred in America between 1980 and 2001: 108 fatalities and losses of hundreds of millions of dollars had resulted. Even then there was little coordinated response until after December 2007 when a massive explosion at T2 Chemicals in Florida during manufacture of a petrol/gasoline additive resulted in 4 fatalities and 32 serious injuries. The company facilities were destroyed and many adjacent buildings were severely damaged, 4 of which were later condemned, see CSB (2009–1). The 2 co-owners of this business had undergraduate degrees in chemistry and chemical engineering respectively yet neither had had any exposure, or training, as part of their formal education in how to assess the exothermic reaction hazards.

Finally the CSB adopted a more proactive role and publically called on the AIChE to work with the Accreditation Board for Engineering and Technology (ABET) to ensure that American undergraduate chemical engineering degrees do educate students on how to recognise, assess and control the hazards and risks associated with exothermic reactions. This is now finally starting to happen in the USA and ABET is revising its expectations in this regard. But, yet again, our ability to 'learn lessons' effectively from the accidents that our industries create was only triggered by a whole serious of repeat events over a long period of time and from which we learned too little.

3. OCCUPIED BUILDINGS

In September 1992 at the Castleford, UK site of Hickson and Welch a 45 m^3, horizontal, still base was being cleaned of residue. Steam was used to soften this sludge and it because it got too hot it started to decompose and self heat. This led to autoignition of the vapours that were generated and a violent, horizontal jet flame was expelled from the open manway of the vessel. This destroyed the plant control room some 25 m away and caused significant damage to a main office building just over 50 m distant. 4 of the 5 people in the control room died as a result as did one additional person in the office building, HSE (1994–1). The HSE accident investigation report listed 9 critical lessons that should be learned. Each of these was quite general, i.e. none were specific to the detailed particulars of the activities being carried out at the time of the accident. We produce lesson 7 in full:

> *"The design and location of control and other buildings near chemical plant which processes significant quantities of flammable and/or toxic substances should be based on the assessment of the potential for fire and explosion and/or toxic releases at these plants. Companies should assess the suitability of existing control buildings and if they are found to be vulnerable reasonably practicable mitigating action should be taken."*

Partly as a result of this lesson 7, the Chemical Industries Association (CIA) appointed a task force to prepare guidance on the location and design of occupied buildings on chemical manufacturing sites: this was first published in 1998 and has been updated twice since then, see CIA (1998). Appendix 5 of the original publication dealt specifically with "Temporary Buildings" and contained the text:

> *"The location of buildings should be reviewed by a competent safety specialist," and later on, "Temporary buildings should be as far as practicable away from operating plant with the ability to generate toxic fumes or overpressure."*

Now let us fast forward 13 years from the Hickson and Welch accident to the 2005 explosion and fire at the BP, Texas City refinery which will be familiar to many readers, CSB (2007): as a result of this there were 180 injuries and 15 fatalities. One of the CSB's key lessons and recommendations from their investigation was:

> *"Ensure that non-essential personnel and work trailers are located a safe distance from hazardous process areas."*

This wording is uncannily similar to that quoted above from CIA (1998). It is clear that nobody at the Texas City refinery had learned the lessons that were clearly set out in HSE (1994–1) or CIA (1998). Why not?

There are many other examples of classes of repeat accidents derived from immediate causes such as tank overfills, offshore gas releases, problems associated with maintenance, inadequate management of change or electrostatic discharges as a source of ignition. We cannot summarise any more in this brief paper, but we trust that details of those that we have chosen will persuade the reader that we (that is the international community of process engineers) have in many cases been very poor at learning lessons from past accidents and that as a consequence it is now time for a paradigm shift in how we try to achieve this.

PROFESSIONAL RESPONSIBILITIES AND THE PARADIGM SHIFT REQUIRED

The late John Bond was an indefatigable champion for a process industries accident database that included lessons learned, Bond (1998). Indeed, it was largely through his personal commitment, and that of BP, that the IChemE

Accident Database came into being. It contains around 13,000 accident records and for about 40% of these there is some specification of 'lessons learned'. But the IChemE chose that this database should be a vehicle for revenue generation (via both the purchase price and the annual maintenance charge) rather than a service that they should offer to their profession. The charges, particularly for SMEs and occasional users were high and consequently interest was lower than anticipated. This database had many excellent features but a recent enquiry to the IChemE confirmed that it is no longer actively marketed, that it has not been updated since 2001 and that no background materials relating to a specific entry can be supplied: the latter was a key element of John Bond's vision.

Many other accident databases exist and the webpage for the ROSS Gemini Centre at the Norwegian University of Science and Technology (NTSU), Trondheim, gives a convenient listing of 17 of these together with hyperlinks, see NTSU (2012). Many cover specific topics, e.g. such as the process industries (eMARS and PSID), aviation ('Aviation accident database and synopses' and ECCAIRS) or road transportation (IRTAD). But how is a young engineer meant to find out which database is best for his/her type of enquiry, how to locate what (s)he wants, how much it will cost, whether the database is up to date and whether it includes 'lessons learned'. Do any of the databases include entries, for instance, from China, the Middle East, Kazakhstan, Brazil or Indonesia? And how is that individual meant to proceed if they are not able to read English, French, German, Spanish, etc? We have to admit that this is not an ideal arrangement around which to have to navigate.

So if we were to start with a clean sheet of paper in 2012, initially just for a process industries accident database we suggest that the following would be a model approach for 'learning lessons':

- Incidents (near misses) and accidents should be competently investigated and reported with specification of root causes and 'lessons learned'.
- Qualifying accidents must be reported as required by national legislation, e.g. RIDDOR in the UK, and there should also be a requirement that these records (sanitized if necessary to remove confidential information) would then also be transmitted to the database organisers. All other bodies including individual companies should also be strongly encouraged to submit their own investigations. Could we get individual commitments from board level personnel within companies to make this happen?
- A new, unified, international database should be created. This might have the following features:
    - Access to the database should be free at the point of use.
    - It should be available in a specified variety of languages.
    - It should be user friendly and searchable in an easy manner.
    - Individual records would be created by the staff employed by the database provider.
    - Where possible for each record 'lessons learned' should be specified.
    - Supporting information, e.g. government reports, articles from conferences and journals, details of seminars, newsletters, video files, etc., would all be accessible via hyperlinks.
    - Control of the day to day activities of the database team would be by an executive director who would be guided by a steering committee.
    - The type of work involved might mean that the database team would not always be required to be geographically close to one another for much of their working time.

To enable this to happen key players have to come together, cooperate, pick up the collective baton and run with it. Their support (moral, financial and logistical) will be required. *This paper is effectively a call for just these things to happen*. Leadership is required from captains of industry, professional societies such as the IChemE and AIChE, interested agencies such as the EPSC or DECHEMA, academic and research organisations such as the MKOPSC, TNO, HSL, Ineris or BAM and departments or parts of national governments such as the CSB, HSE or OSHA. Ultimately we will require the active support of governments or supra-national bodies such as the EU. Other interested parties should include regulators and those who define international standards as well as trade groupings and representative bodies e.g. from the oil and gas industries, pharmaceutical providers, the fine chemicals sector, insurance companies and SMEs. Admittedly this listing is unacceptably biased towards North America and Europe: that is simply a reflection of our particular backgrounds and the list is by no means intended to be exclusive. Is this type of collective action too much to ask for, or expect? Well, we don't think so – *at least not if we truly believe that safety is paramount*.

The main resource required will be a long term financial commitment from key players (say ideally for a minimum of 10 to 20 years). This will be significant but miniscule compared with the costs of a single accident of the types that we have mentioned in previous sections. The level of finance required might be significantly reduced if a single organisation, or country, could agree to host the database long term, i.e. to provide all the necessary facilities for staff and the required computing and IT infrastructure. Other organisations might agree to second one of their employees to the database team for a fixed-term period or to cover the salary of one such person. This might be particularly appropriate for those nearing retirement age and with a wealth of relevant experience. Individuals with such from the process industries, e.g. in accident investigation, and in computing, software development, database management, search engines and IT will have to be recruited. A multi-lingual database would require translators to be available. A help line may need to be set up and staffed. We certainly need to 'think big' and, under no circumstances, must the 'profit motive' creep in and be allowed to usurp or derail this project.

NECESSARY FEATURES OF AN ACCIDENT AND INCIDENT DATA BASE

It must be easy to search the database quickly to find what you are interested in. To this end we suggest a structure similar to that used in the IChemE database. Each entry would be categorised under a number of standard headings such as *activity, equipment, scale, immediate results, consequences, chemicals/substances, type of location* and *'lessons learned'*. Lists of categories for each heading would be available and each could be searched as well as logical intersections of headings and/or categories. For instance the user would be able to search for all accidents involving pilot plants, or more explicitly just those that involved pilot plants, gas escapes and subsequent ignition and fire: any combination of intersections could be searched, thus enabling the user to refine searches so that the eventual number of database records that were revealed were of a number that could be conveniently handled. Or someone preparing a permit to work scheme could quickly search all records with lessons that related to permits to work, and then refine that search so that it only generated those records that were for hot work permits or confined space entry. In a similar manner, any record that had associated lessons about evacuation and roll call in an emergency could immediately be identified.

Our initial proposals concern the area of process safety. Eventually the same concept might be rolled out to make the database much more all-embracing, so that it could be divided into sections (all still searchable) that included accidents of a natural, aviation, maritime, road transportation, nuclear, civil, mechanical or electrical nature. Many lessons derived from such accidents might be very relevant in other areas of endeavour including the process industries.

SOME CONCLUDING REMARKS INCLUDING THOSE ON AN ELEMENT OF COMPULSION

The old saying is that you can take a horse to water but you cannot make it drink. The same will be true of the database that we advocate. We hope that we have demonstrated convincingly that over hundreds of years our voluntary regime for 'learning lessons' has failed to deliver the performance that we require. Therefore to force people into regularly using the database as a resource might require an element of compulsion: we only go so far as to say "might". Ultimately, this could only be imposed by professional bodies who can dictate that membership entails signing up to certain codes of conduct, or by governments who can legislate to achieve the same end result. Insurance companies could of course make use of the database a pre-requisite for insurance cover. So it could be that for any entirely new process industries project, or for a capital project on an existing plant, that a designated board member would have to sign a document to personally confirm that all reasonable efforts had been made to incorporate 'lessons learned' into the new designs, work activities, start up and production, etc., this to have included detailed consultation of the new accident database. More broadly this same person could be required, perhaps annually, to confirm that the company has created a regime within which their key employees are required regularly to consult this database and to disseminate relevant lessons learned within their own organisations. If this is to be successful then penalties levied on both individuals and companies, financial or otherwise, would need to be applied in cases of negligent non-compliance. We think that this would be likely to be a successful mechanism for focussing the attention of at least one responsible member in every company boardroom on whether they are trying to 'learn lessons' in a professional manner. It is only when there is sufficient transparency to see that such a robust regime exits, and that it has "teeth" that we can start to hope that the public, particularly those who are neighbours to our sites, will have growing confidence that we will operate our research, production and storage activities in an acceptable low risk manner. Until that happens we can anticipate that the "nimby" sentiment will continue to flourish – and in some senses we will only have ourselves to blame for this.

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