

LESSONS LEARNED EQUALS IMPROVED SAFETY CULTURE

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This paper is a challenge to all processing companies to adopt a new approach to the use of knowledge gained inside or outside its area of expertise to change the safety culture of the company. It argues that first there has to be a corporate culture from the top down which is open and willing to learn lessons and then the determination to put those lessons into place. It also argues that there has to be a more open approach within the process industry and from the Regulator, with the willingness to exchange news, good or bad for the benefit of all.

The collation of lessons learned, their distribution and teaching of those lessons will require a senior role who will command the respect of the senior and junior managers and who will have to develop new skills, which will involve "networking" in and outside the company, interpersonal skills, investigative skills and finally teaching and projection skills.

Finally, the body corporate has to take on the ownership of the lessons learned to achieve an improvement in then safety culture.

KEYWORDS: Culture, Lessons Learned, Databases, Cultural Change

INTRODUCTION

The definition of the word *culture* in Oxford English Dictionary is *the arts, ideas of a nation, people or group.* This means that any change in culture will be slow due to the inherent resistance to that change, as, by definition the culture will have evolved over many years and the group will feel happy with it, perceiving that there is no need for change. This is to be found in many organisations particularly following take-overs by other companies where there is a resistance to a change in the culture. However the culture may be one of complaisance and flaws may have become incorporated within it over the many years of its evolution. A point noted by Robens [1972] and still valid today.

Culture is an engineering paradox; it has no mass but high inertia!

There has been recognition in recent years that the general safety performance is not falling at the rate that the Government and the Regulator would wish. This has been discussed in many papers and need not be elaborated upon here. Recent press reports suggest that the trend is actually rising for the first time for some years. However there is a clear loss of analysis and a lack of detailed examination of the lessons that should be taken out of any event be it inside or outside the industry of interest. The reasons for this have been discussed in various papers [Crawley 2006, 2007] and have been put down to a number of causes including, lack of mentoring and training, a parochial approach to ones own industry, poor review of and improvement in corporate design standards due to the lack of in-house engineering resources, and the inability to see the problems, or to challenge a design feature, under the pressures of keeping projects "on time and on budget". There is also a potential flaw in the use of "standards" as the historic reason for various requirements or features has become lost in the mists of time with the inevitable reaction "I do not see the need for this, so, I will not apply it!" (Is this the corporate half life or is it more fundamental?) The analysis of the Buncefield Fire [Martin 2007] gives many pointers or lessons which do not apply uniquely to fuel storage (such as mass balancing) but also have application in other storage and processing industries.

More recently there has been a lot of attention given to databases and their usage [OECD 2005]. Undoubtedly databases do contain much information but they are not always totally accurate for reasons of confidentiality, they dwell on the lead up to the incident and how it was handled and it is not easy to extract the "lessons learned" from them as they pertain to a specific company. It may well be that the culture of Company X has those lesson to be learned under strict control but in Company Y they may not be so well controlled and it may be difficult for Company Y to recognise this failing and to take the appropriate actions. The inevitable question is this – "How can we find the lessons to be learned, how do we incorporate them into the company and how do we influence or change the culture?" Particularly where there is a resistance to "lessons learned" from incidents outside a single industry. It is suggested that there may be more significant cultural issues which require to be changed.

However, when there are changes they have to be managed or incorporated properly to ensure that they do not incorporate worse problems!

The resistance to lessons learned is exemplified by the analysis of the issues associated with Offshore Relief and Blow-down Systems [RABS 2001]. First, there was some reluctance to accepting that the problems were not company specific but were industry specific and that each company had found its own solution and failed to see the better industry solution. In other words there was a resistance to c*ultural change*. Second, there was initial reluctance to the exchange of information on incidents. This was overcome by the simple expediency of eliciting information by showing that the problems were not company but were industry specific. This could not and would not have occurred in total isolation and required facilitation and a dialogue which discussed incidents or examples outside the industry and allowing members in the team to recognise the parallels within their industry. This required a very "open approach" from participating members and the willingness to listen.

ARE THERE SOLUTIONS?

Before this question can be answered it is important to understand what *culture*, and more particularly what *safety culture*, actually means. While the OED definition might be applicable to a Nation or possibly a company it does not necessarily apply totally to *safety* *culture* and requires further expansion. There are many forms or sub-sets of safety culture which are given by Hudson [2001]. These are

- ***1 Pathological*** **–** Safety is regarded as a problem caused by worker, the main driver is the business and a desire not to be caught by the Regulator. The Organisation cares less about safety than about being caught.
- ***2 Reactive*** **–** The organisation starts to take safety seriously but there is action only after an incident has taken place.
- ***3 Calculative*** **–** Safety is driven by management systems, with much collection of data, rather than learning from it.
- ***4 Proactive*** **–** There is a realisation that with improved performance the unexpected is a challenge; workforce involvement starts to move the initiative away from a purely top-down approach.
- ***5 Generative*** **–** The safety behaviour is fully integrated into everything the organisation does, there is active participation in safety at all levels, and safety is an integral part of the business. Organisations at this level are characterised by the term "*Chronic Unease*".

1 is clearly unacceptable, 2 is probably more representative of the past, 3 is probably representative of the present National Health Service and was part of the BP culture in Texas City [Baker 2006], 4 is more the present approach but 5 is the *Holy Grail*.

Bond [2007] discusses the Just Safety Culture which is given the definition; "*A way of thinking that promotes a questioning attitude, is resistant to complacency, is committed to excellence and fosters both personal accountability and corporate self-regulation in safety matters*". He also introduces *Operational Monitoring* which is a new term for what was called condition monitoring and key process parameter trending. One trend which should be monitored is the drift in a materials balance across a section of plant – see later.

The closing point made by Bond is as follows "*Adoption of an Operations Monitoring system combined with a Just Safety Culture approach would give a new emphasis to improving safety by sharing accident information*".

The only relevant issue not discussed but is probably included implicitly within these definitions, is the *open* and *no-blame culture*. The conclusion to this analysis is that to achieve a significant change in safety culture there has to be the correct organisational culture, open and no-blame, followed by a top-down and bottom-up approach to safety. This prerequisite is due to the fact that the safety culture is a sub-set of the corporate culture and if the corporate culture is not appropriate the safety culture will suffer. Hence there must be a corporate culture which may have to be a change at all levels to ensure that the safety culture is appropriate.

PROPOSED WAY FORWARD

Clearly there have to be solutions but before these can be put in place there have to be so prerequisites. First there has to be an *open attitude* to the analysis of incidents inside and outside the specific company, that is, there can not be a parochial approach. Second, incidents must be examined by the use of the "***WHY?***" questioning approach which should be targeted at the identification of the *Root Cause* of the incident. Third, there has to be the recognition that cultural changes may be painful. Fourth, there has to be an acceptance that in any vital and alive company changes in culture are a necessity of its own development and there has to be the correct culture within the company which is willing to accept the changes that will result – the *generative* approach [Hudson LP2001]. The body corporate then has to take on the ownership of the lessons learned so as to improve its safety culture.

Before reinventing the wheel it is worth looking at the events of the past discover if these problems have already been addressed, in part, elsewhere. Someone, somewhere must have had to face up to them and may have found forgotten solutions. In other words "There is nothing new under the Sun!" This can be illustrated the simple "lesson" of mass balances, (a lesson taught very early in any Chemical Engineering Course but then forgotten in real life), which was relevant in two major incidents Texas City [Mogford 2007], where a Distillation Column was overfilled due to instrument errors and also Milford Haven [HSE 1997], where there was a major recycle of fluids in the blow-down system. Nearly 40 years ago during the Initial Start up of a Plant there was the unexpected rise in the pressure drop across a Distillation Column. The pressure differential stabilised after about one hour but was significantly higher than expected. A simple mass balance around the Distillation Column was carried out over the previous two hours and an imbalance of over 10% was identified, representing a major hold up of process fluids within the column. The immediate reaction was that the "instruments were in error" but the error was too high to be real and a further mass balance over the previous day showed no faults. This represented use of a simple form of Operations Monitoring [Bond 2007]. Feed into the column was stopped and the pressure differential remained elevated even without reflux and re-boil so clearly there was a choke within the column – or was it instrument error? Within an hour the pressure differential suddenly fell to zero and the base level rose rapidly [PE]. Clearly there was a significant hold-up of process fluids within the column and to proceed would have lead to a major upset. The lesson that was learned (or was not forgotten after leaving University) and is relevant to all industries and was relevant in Texas City and Milford Haven and Buncefield is that during non-steady state operation which will include start up, shut down and upset conditions, Operations Monitoring, or monitoring/trending the inventory, on a continuous basis in each section of the plant MUST be in place. Why was it not done in the three cases quoted? Is it a lack of training or a lack of appreciation of what is actually happening? (Follow the book and do not think!) It is not "rocket science"; it was used on other situations nearly 40 years ago but was forgotten, Operations Monitoring is just good Chemical Engineering. There are many key parameters that can be monitored other than mass balances, including:

Heat transfer coefficients – to detect fouling
Pressure drop parameters in distillation columns – to detect fouling or tray damage
Thermal imaging – to detect faulty electrical equipment or even to scan the internals of a unit
γ-Ray scans – to detect build ups of solids in equipment
Compressor or pump efficiency – to detect fouling or wear

Vibration monitoring and analysis – to detect mechanical wear or faults
Acoustic monitoring – to detect leaks in piping or heat exchangers
Oil monitoring – to detect wear and predict the life of the unit

All of these tools have been used by the author and found to be of great use in condition monitoring.

It follows that the design of the Plant must incorporate the instruments required to mass balance each section and to monitor the key parameters. It follows that there has to be a cultural change in the design house that requires the analysis of the design to ensure that all of the diagnostic features (which may or may not be flow meters) are incorporated into the final design. One of the findings of [RABS 2001] was that the instrumentation of the Flare Knock-out Drum was insufficient to carry out simple diagnostics, particularly the source of major inflows of fluids and a mass balance across the Drum with the resultant likelihood of over-filling leading to liquid carry-over. (This occurs about once every two years in the North Sea.)

By the same argument the HAZOP process must adapt such that it is able to analysis the diagnostics – the parameter could be *inventory* or *performance* and the deviation could be *change*. Another lesson that should be learned. Then, if it is not integrated into a control or data recording system, the operations team must be given the basics training of carrying out mass balances or performance parameters and a comprehension of why they are necessary and the significance of any change, a lesson learned in the Longford fire [Hopkins 2000].

It is now worth examining the lessons to be learned from Chernobyl [Franklin 1986] and the Ramsgate walkway collapse [Crossland 1999]. While these occurred in two different industries the lessons are relevant to the process industry. In both incidents there was a plan for the execution of the work but equally the plan was changed without being subjected to an adequate review. At Chernobyl there were a number of delays which lead to the poisoning of the reactor resulting in poor reactor control. More particularly the longer the plan deviated from the objective the greater was the likelihood of the final event. At Ramsgate the bridge was not the correct size (measure twice and cut once) and required an on-site modification. In both cases the universal lesson to be learned is that once a plan can not be carried out fully and as intended there is every possibility for the incorporation of hazards and the work must be stopped immediately the plant or work revert to the previous state and the situation analysed in detail.

USE OF DATABASES

Can the information within the databases be used to identify the lessons? The answer to this is a guarded "Yes!" There is a slow change within databases from the traditional record of the sequence the events to lessons learned, so, extracting the lessons may be easier, however it is likely that the lessons may be more difficult to extract from older databases if the data is not accurate and is insufficient detail. Too often the cause of an incident is put down to the catch-all "human error" and then the detail stops. Human error is actually *management error* or a pitfall put in the way of the operations group. If management do not recognise this pit-fall it is a management error and the lesson to be learned will most certainly not be "improved training". This is particularly important on the more complex an integrated process plants. The fault in a valve design mentioned by Kletz [1999 (1)] was repeated elsewhere in the same company with a different valve design [PK] when a fitter broke the low pressure flange on a recently fitted ball valve, with the resultant a loss of confinement. The valve had been put in back-to-front and as installed the seat and ball were only retained against the pressure source by a grub screw, used only for assembly. The correct configuration was for the seat to be self activating and retained, on the pressure side of the valve by the upstream flanges. The fitter had assumed that the valve as a typical ball valve ball valve where the internals are fitted through a split joint in the valve and so the ball and seat were self retained, however there had been new design feature which had not been recognised by the engineer and explained to the fitter. This was clearly *management error*.

The HSE also issue Safety Flashes which report the incident and then require action by the recipients. These are potential sources of lessons learned but the request from HSE is usually in the form of "carry out an inspection" and the Flashes do not necessarily report on the detail in the flaw in the design or operations process.

It is also most unlikely that the Lessons can be extracted by one person working in isolation; it will require a small team to discuss the issues using the *WHY?* approach to identify the *Root Cause(s)* and then to draw out the correct lessons. Then the lesson must be formulated such that it is relevant to the industry, this may require some thought and may take time. Just as with RABS it will be necessary to elicit the relevant information using technical skills and experience. It is possible that the finer details, from which the lessons learned will be drawn, may not be available and then it may be necessary to obtain that detail by direct contact. There may be pit-falls here as discussed in the Hazards Forum [2006]. Some of the impediments to learning and information transfer come from the fear of litigation, a situation which has happened in the past, over regulation, increased media and pressure groups demanding accountability. This may require a change in the approach of the Regulator from the whip to the carrot!

The lessons may be well disguised and require to be extraction with care. The work will have to be carried out only in areas of concern and not reviewing trivia as the rewards must be proportionate to the effort. This in turn will require a depth of experience to separate trivia (or not critical lessons) from the underlying problems. There is an opportunity for an Academic or Learned Institute or the HSE to take a lead in this work utilising the skills and knowledge of retired professionals. Some of the lessons learned can still be found inside the Hazards Training Packages produced by the IChemE; however it is for the individual company to draw out the lessons learned and this may require new training skills and experienced personnel. (Is this not just part of the ***generative*** safety culture?)

As part of the change in safety culture it is essential that there is a change in the approach to incidents from recording the historic detail to the recording this and also the lessons that should be passed on. They should also include the "near misses" where the organic lessons to be learned will be found. This will mean that there must be new investigative skills. There will likely be more investigations and reports and these reports may have to be in more detail, may take longer to write and require more analysis (in conflict with lean and mean). This is also a symptom of the ***generative*** safety culture.

The next point that must be considered is what is to be done with the information and lessons learned. There is little point in each company inventing, or worse still re-inventing, the same solution. This clearly points to the need for a collection and distribution point [Hazards Forum 2006]. One such point could be the IChemE via the EPSC and another could be the HSE but in the latter case there must be a form of immunity from prosecution, this is unlikely. There are two particular industries where there should be an "in-house" collection system, the Nuclear Industry via UKAEA and the Offshore Oil and Gas Industry via UKOOA. An informal distribution, as was witnessed by the ICI Safety Newsletters, did achieve a cohesion in the Loss Prevention fraternity but it tended to be biased towards one company and suffered when the company was sued for not reporting an incident later reported in the newsletter in good faith [PC].

ROLE OF THE KNOWLEDGE MANAGER

The Knowledge Manager must have a number of attributes. He/she must be proactive and not reactive and have the authority and support of all levels and all disciplines in the company from the highest level and may have to carry out the role. The Manager must be accountable and responsible for the role. This profile is not easily matched!

The Knowledge Manager may have to develop a number of new skills. One skill will be the ability to elicit information from persons inside and outside the company; this in turn will require "*networking*" either officially or unofficially. Another skill will be the ability to find the *Root Cause* of the event, be it a real event or a near miss and then to convert this into a meaningful lesson. Finally, the lesson must be taught and corrective actions put in place, be they procedural or hardware. The harsh reality is that there is probably more to be learned from "*near misses*" that the less frequent incidents, this will require not only an open culture but also man-management skills and credibility such that the near misses are first of all reported promptly and then are investigated urgently. The problem may be that the Supervisors may not recognise that a near miss had occurred. The lessons learned can be both corporate and industry wide. The lessons must be distributed both upwards and downwards. The lessons from other industries must be analysed for relevance and for potential lessons for another company. Too often there is the expression "This does not apply to us!" Yes it does! The art or skill is to put the lesson learned it into context for the second company. This is not always easy but must be part of the role of the Knowledge Manager.

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Knowledge Management is a tool being discussed in many conferences. It does not occur spontaneously and must be managed actively bearing in mind the tendency for corporate memory fade, or is it memory fatigue? Knowledge must also be recycled not only to the operations group but also to the engineers. The latter is not evident in many industries with the trend to *Engineer, Procure and Install*. In these the corporate operations and engineering lessons learned, which are often to be found in the Corporate Codes and Standards, are not used in favour of some other codes. A simple review of any Corporate Code will usually show those features that arose from an incident some years ago. These can not be captured so readily by Design Houses unless there is an attempt to treat each piece of equipment as a standardised set of lessons, some of which may be irrelevant to some industries. In addition the objectives of the design houses are not necessarily in harmony with those of the operator. One lesson that must not be forgotten, or re-learned, is that codes and standards represent part of the corporate culture; they must not be forgotten and must be reviewed for accuracy on routine.

It is an unfortunate fact that those Scientists and Engineer who should be reading the *lessons learned* do not do so for many reasons. The Knowledge Manager must keep the lessons learned vital and there must be means of publicising them on a routine so encouraging the learning of the lessons and the assimilation into the working culture. This may require a significant budget. The bland use of "time since the last LTA" is not appropriate and campaigns are more likely to produce results. These can be viewed as re-enforcing campaigns designed to overcome memory fade. One other means of re-enforcing is the use of incidents outside the company and using the lessons learned from these to illustrate where the present company had the correct systems in place or where new systems must be devised.

Finally, and this may be at variance with the constitution of the regulator, the role of the regulator should be more open and supportive. This will involve giving advice, support or guidance and not instructions.

CAN WE USE THE LESSONS LEARNED TO CHANGE THE SAFETY CULTURE?

The answer to this question posed in the title is certainly – YES. However it will be necessary for the corporate culture to be receptive to changes and for the management of the lessons learned to take a much higher profile within the company with a leading figure, known as the Knowledge Manager having a high profile within the organisation. The framework of the role or job description of this person has been given. Actions must be spontaneous and prompt the solutions identified and implemented while the history of the incident is still real in peoples minds. Equally important is that the "lesson-to-be-learned" is recorded in the corporate archives for future reference and education. It has occurred in the past and with the will and direction it will happen for the benefit of industry as a whole and the Company in particular.

It is then for the body corporate to take on the ownership of the lessons learned so as to improve the safety culture. This has to be an iterative process to overcome the corporate memory fade.

CHANGE IN SAFETY CULTURE – THE EXPERIENCE OF ONE COMPANY

It was proposed earlier in this a paper that someone, somewhere had found solutions and that it was not necessary to re-invent the wheel. Kletz [2006] discusses the organisation within ICI in the 1960s and how the whole *safety culture* changed. The lessons learned and their influence on the company safety culture can be illustrated by just 4 examples taken at random. These are now part of the process industry safety culture.

1 In the 1960s there was a release of chlorine in an ICI factory in Merseyside. The cloud drifted across a school playground and some of the children were kept in hospital under observation over night. It would have been easy to examine the process and to propose engineering and procedural modifications but the *Lesson Learned* from this incident was that the root cause was a flaw in the design reviews which had not identified the design faults/errors during the design process. From this the traditional *6 Stage Hazard Studies* were developed (now 8 stage). The design culture of the company had changed.

2 Likewise in the 1960s the evolution of novel and large process plants resulted in some unexpected process problems. Once again it would have been easy to propose engineering and procedural modifications but the *Lesson Learned* was that root cause of the operational problems had not been identified and corrected "on the drawing board". The solution was to be found in an evolution of method study technique it then was given the name of *The Hazard and Operability Study* (HAZOP). Once again the design culture had changed and a new name (HAZOP) had been introduced into the industry.

3 A fatal accident [Kletz 1999 (2)] resulted from the poor operation of the permit to work (PtW) system. The PtW had been prepared by the previous night shift but signed on by the following morning shift, one of the root causes. Another of the root causes was that the oncoming shift was in work over-load as they had been on rotation and the Supervisor was trying to follow up all that had happened over the previous 3 days while trying to issue numerous PtWs. The *Lesson Learned* was not that the *Permit to Work System* was flawed but that root cause of the accident was the implementation of that system. It would have been easy to examine the permit itself and to propose changes to the permit but this would not have improved the implementation. This resulted in all Plant Managers talking through the incident with EACH shift pointing up where the implementation had failed. Further each month the Plant Manager was required to audit the Permits for that month, to identify weaknesses in the drawing up of the permit and to put into place improvements in the implementation of the PtW. This was written up as a report which was sent to the Works Manager. The operating culture had changed and the approach to all work under permit was subjected to a more critical analysis.

4 Finally the follow up to the explosion at Flixborough resulted in the realisation that to root cause of the incident was that of change, small or large, had to be *managed* [Henderson 1976]. All changes were subject to a detailed and recorded examination before they were implemented. The operational culture and approach to "changes" had changed. This process is now known as "*management of change*" but it is not recognised that a change in management must be managed with equal vigour.

POST SCRIPT

ICI was the source of many innovative systems in the fields of Loss Prevention. Many have been adopted by other companies and their origins have become lost in time. As of writing it might appear that ICI will cease to exist.

Let us hope that the words of W Shakespeare in Julius Caesar are not applicable to ICI,

> *"The evil that men do lives after them,*
> *The good is oft interred with their bones."*
> Act II Scene II lines 67–68

ICI taught us all many lessons – now, it would be a compliment to those pioneers who devised them if we incorporate them into the *corporate safety culture*.

Note: PC Private Communication; PE Personal Experience; PK Personal Knowledge

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