Corporate Memory – the Collective Brain and the Struggle Against Amnesia

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This paper discusses the problems of maintaining awareness of known risks in organisations whose operations involve hazardous chemicals, where typically knowledge of the risk and mitigating measures against that risk are held by different groups, often in different formats. It is an issue the authors have repeatedly encountered, having spent many years assessing sites for insurance against property damage and business interruption loss - and in consultancy whilst implementing safety solutions that involved different areas of organisations working together.

Presenting a structured paper, based on observations of information management is not easy, as practices will vary from owner to owner, but some common themes emerge. At the end of a visit to a refinery in mainland Europe, the director of the site left us with a plea: "How do I make the knowledge in the departments in my refinery and the experience of my workers available to the next generation? I may have procedures, but they don't always say why something is done. I may have information, but I can't guarantee that it gets where it is needed." One might imagine that this is a trivial problem, however, where hazards arise as a consequence of combinations of failures in different areas of an organisation, it can be a widespread issue.

We have had experience of working with both small and large organisations. Although it might seem paradoxical, small organisations can often perform as well as, or better than, large ones. When asked why, the answers will involve shorter lines of communication and knowing each others' business and priorities.

The growth in information on modern sites should make decision making a dream; there are corporate standards, risk assessments, inspection, maintenance and operation information. Of course, the problem is to bring all that knowledge off the shelf, to assimilate the relevant information in real time, to diagnose the issue at hand, assess its threat and apply a solution.

Some advances have been made. For example, control systems can present issues like instrument outage and much ancillary information beyond the live and recorded readings of process parameters on site. On the other hand, it is not normal for the control system to embody a significant amount of contextual safety information when, say, a troublesome trip bypass is being considered.

In other areas of plant management there are different issues. In areas such as inspection, historical paper-based information is valuable, but can take years to put in a useable electronic format. Then there is the problem of making design hazard assessments "live" documents. Would it be helpful in a plant upset condition to know what the opinion of the HAZOP team thought of this particular deviation from normal process conditions? (and how would the accuracy of the HAZOP be maintained?).

Thus we have found that the facilities that are the subject of this paper are information rich, but without the information getting where it is needed, they can be knowledge poor.

This paper shows where there may be benefits in providing relevant data to personnel directly involved in operating and maintaining hazardous processes It also addresses the problem of succession planning, especially in regards to plant that itself is aged.

What is Corporate Amnesia?

Ownership and Knowledge

This paper deals specifically with corporate technical amnesia. Knowledge, in this context, is more than the information that is available. It is something used by the personnel on a facility or in a company. Thus it is information plus the application by the owner or owners, who understand the rationale for the collection of the information and how to apply it.

Corporate knowledge is that information shared by several owners and decision makers. Corporate amnesia is the forgetting by one or more parties either of the collection of the information, the rationale as to why the information is being collected, or that it needs to be distributed. This paper deals with information and knowledge that is safety related, so the paper should be about Corporate Safety Amnesia and Corporate Safety Knowledge, but "corporate amnesia" and "knowledge" are used as short hand.

Continuing the diagnostic analogy, amnesia may be caused by:-

- Failure to hand over design rationale information between design stages or from designer to operator;
- Failure of ownership of knowledge during facility ownership transfer;
- Failure to preserve existing knowledge during a change to working practices;
- Change or upgrade of control systems;
- Failure of internal knowledge transfer – succession planning;

- Failure to implement learnings from internal and external incidents;
- Failure of external knowledge transfer – risk ownership by contractors;
- Rotation of shifts, operations crews, without complete handover; and, most importantly
- A simple lack of communication between groups, from whatever cause.

These can all contribute to an organisation knowing less in the future than it does now and the key contributors to the transition from a state of more knowledge to one of less knowledge are the failure of new personnel to be given or to adopt available information. Within a successful transfer process, knowledge ownership and responsibility are key.

Economic causes of a failure to acquire knowledge can arise in different ways. It is perhaps not too unusual for organisations whose relationships have been troubled not to share any more information than is considered absolutely necessary, causing gaps to arise. It can also arise in rather less obvious circumstances. The authors have been on survey to several sites where 3rd party ex-patriot contractors were employed, whose families depended on their remittances. The fear of being fired led to a substantial proportion of the staff being unwilling to ask the degree of the sour gas hazard on the plant, which in turn contributed to the severity of the releases that occurred.

Ageing Workforces, Ageing Installations

People and plants are not getting any younger. This is particularly true in high hazard industries. The UK has been a developed country for several generations with little growth in fuel consumption, so most refineries in the UK are more than 30 years old (ref. 1). Even in the offshore oil industry, where fields have a limited lifetime, most of the current development is in tie backs to existing infrastructure, which is over a decade old. Recruitment to the engineering profession has also suffered from changing attitudes to working in industry and though its value has been appreciated recently, there is still a major demographic problem and this will remain as Science, Technology, Engineering and Maths (STEM) graduates are also in demand from other high tech industries (ref. 2).

Companies' Relationship with 3rd Parties, Suppliers and Future Owners

Increasingly, companies also sit in a network of relationships where much of the knowledge is proprietary to the suppliers or contractors. Loss of knowledge can be as simple as a change in the technology used by a supplier to inspect an item of equipment or as major as a dependency on external companies for whole areas of operations. Key areas are:-

- Vulnerability to obsolescence of equipment or processes;
- Adherence to OEM recommendations for equipment maintenance, inspection and operation;
- Knowledge of critical vulnerabilities caused by instrument unavailability (e.g. SIL levels, trip set points and so on);
- History of second hand equipment (when selling on disused refinery equipment for example);
- Due diligence in merger and acquisition (M+A) processes.

An example of the above can be found in the countries of the former Soviet Union. Here plants are undergoing transformation as they adopt to a greater or lesser degree Western working practices, operation software, design codes and so on. This can lead to the highly qualified workforce finding it difficult to:-

- Retain design margins;
- Maintain their positions in the company; and
- Ensure that the new is an improvement on the old.

Maintenance and Inspection functions are very often outsourced. This is not necessarily a problem provided that there are good procedures and standards in place. But this practice becomes a problem we believe when there is inadequate supervision and monitoring by the operating company. We have even seen "100% outsourcing" where the operating company has handed over the complete Inspection and Maintenance functions to a contractor, including management and production of Key Performance Indicators (KPIs). It is essential that operating companies have their own qualified staff in these two key disciplines to oversee the activities, to set the standards to which contractors should perform, to develop those standards from industry learnings, to set KPIs, to review inspection data and to ensure that there is corporate knowledge and information to be passed on. In larger organisations we would also advocate a Contracts Manager position to oversee all outsourced activities.

Maintaining and Retaining an Agreed Engineering Standpoint

There is an old story that a frog placed into hot water will leap out immediately, whereas one can place a frog in cold water and by gently heating the water, one may boil the frog without the frog becoming aware that it is moving from a safe state to

a dangerous one. In an age where we hopefully treat animals in a humane fashion, this cruel conjecture is only of relevance when considering how the operational and commercial aspects of a company influence each other. The point is that by a process of gently shifting baselines, an organisation can unknowingly move from a safe and comfortable position to a dangerous one without anyone becoming aware.

There are many issues on sites whose traits are analogous to the gently simmered amphibian, such as extending turnaround times on refineries and investment in corrosion management. In the case of corrosion management, the timescale of the developing hazard can bridge the typical lifetime of personnel in the organisation, potentially making the effects of decisions "somebody else's problem". In other cases issues like bypass of trip systems and deferred maintenance have the characteristics of being apparently acceptable, being nearly invisible, encouraging a derogation of the norm and most of all being inexpensive at the time of decision. Individually or collectively, they are dangerous both in their deceptive practicality and the difficulty of the appreciation of their effects. They also have the characteristic that in certain parts of the facility, inspection will show that they are apparently acceptable. Because they are systemic, however, they need to be demonstrated to be acceptable in every single application of the changed rule. Demonstrating this may incur greater costs than have been saved by implementing the change.

If one characterises the technical side as prudence and the commercial side as squeezing every last dollar of profit from a facility (and why not, this is an engineer's conference) then the analogy becomes clearer. At what stage should the operators "hop out" of the hot water, tell the money men that enough is enough, the plant needs to be shut down to check the integrity of the equipment? Remember, technical and commercial are not two different companies, but competing drives within the same company.

Thus, above all, a corporate body must have the ability to balance itself based on knowledge, agreed channels and procedures of communication and to be able to check and retain its own position against those standards. It also needs to be based on a whole facility life approach (and therefore have an implicitly long term view).

The Limits of Experience and System Solutions

One of Trevor Kletz's best contributions to industrial safety in ICI was his awareness that some industrial accidents were too big to be allowed to happen. Incidents such as Piper Alpha (ref. 3), Bhopal, Toulouse (ref. 4), Macondo (ref. 5) and others have demonstrated that the industries in which we work have the potential for overwhelming, severe consequences and in some cases an enduring toxic legacy.

Systems-based assessment by Kletz and engineers in the nuclear and aerospace industry during the 1960's and 1970's promoted the use of fault and event trees to derive the routes through which major accidents could occur, and the layered defences that were needed to reduce their frequency to a tolerably low level. These fault and event trees are employed in the process industry today as "bow-tie" diagrams.

The bow-tie philosophy in process safety is a good example of how companies can understand how individual failures, that they will see, could contribute to the rare major incidents that hopefully they will not. The test of corporate memory for companies with complex operations is how they maintain their awareness of the rare events that an internal risk assessment group alone can model and mitigate. The point to be made about bow-tie diagrams, of course, is that they inherently embody information in widely dispersed areas of an organisation, such as asset integrity, safety and consequence assessment. Overlaid on the existing operations of the facility, they are its hazard knowledge and are a vital living assessment of the entire operation. When individual equipment items are taken out of service or working practices changed, it is only the bow-tie that will reveal how holes are being punched in the layers of defence.

It is also important to be aware that risk assessment has its limitations and that technical risk assessors are as vulnerable to errors as other forecasters.

This point has been vividly reinforced in recent years as:-

- terrorism has changed the baseline of the likelihood of remote events - and what people may do with knowledge of major hazards;
- following the Tohoku earthquake Japan suffered 3 reactor meltdowns in the same week (a supposedly 1 in 20,000 year event (ref. 6);
- bp found itself unable to apply traditional blow out mitigation measures and outflow estimates to the release from the Macondo well.

Despite the above, the bow-tie method is an excellent way of quantifying the likelihood of rare events from the experience of more common incidents. Not only, it draws information from different disciplines, in the manner that we have recommended in our proposals for a corporate nervous system. That is, constructing a bow-tie diagram puts an organisation in a group learning environment.

The Corporation Learning from the World Around it

One of the valuable aspects of organisations such as the IChemE is precisely that they foster communications and learning. Corporate learning and communication can also be said to exist and may be exemplified by development of and adherence to standards such as ISO, API, NFPA or others. Organisations can also learn from culture changing events such as the report into the Texas City accident (refs. 7 and 8), which provided a springboard for the advancement of process safety. Sadly, this is not always the case, even though other people's accidents are a much cheaper way of learning than having them yourself.

Where learning would create considerable cost for the company, such as in the case of management of corrosion on a barely profitable refinery, then the remedial work that is a consequence of that learning may not be done. In some jurisdictions, despite there being a clear pattern of failure to learn, such as with the prevalence of accidents resulting from fuel gas blows in the US, lethargy can resist solving even the simplest problems (ref. 9). In circumstances such as these one should remember Richard Feynmann's reflection on his involvement in the investigations on space shuttle safety, following the Challenger disaster "*For a successful technology, reality must take precedence over public relations, for nature cannot be fooled*."

Incidentally, his appendix (ref. 10) to the Challenger commission report has an interesting comment on quantified risk assessment, which is also relevant. The failure rate of a solid rocket booster (SRB) was quoted as 1 in 50 by Morton Thiokol, manufacturer of the booster. Unfortunately, the assessment was made that the shuttle would only fail if both boosters failed, which was given as a failure rate of 1 in 50 squared, or 1 in 2500. If the assumption is changed so that the shuttle failure occurs should either of the two SRBs fail, as in fact happened, then the failure rate is 1 in 25. The Challenger flight was the 25th shuttle flight. Statistically, one would then expect a total loss due to this cause a little sooner than the 25th flight, but the main message was that the way the assessment was done resulted in a completely misplaced sense of false security being communicated between Morton Thiokol and NASA.

How Can Corporate Memory be Assessed?

If one imagined members of the marriage counselling service Relate turning up one day at the gates of an industrial facility, how much work would they find? Who would sit, wringing their hands, complaining that they are not being listened to?

More seriously, management consultants are often brought in to listen to and diagnose the internal issues of corporations, however, an external non-technical body would only be able to collate what it was being told. One needs to be able to anticipate both the hazards and the problems that failing to manage them properly would create. Is there a framework that will capture both the problems that a company's workers will admit to (remember the facilities where the staff do not know the concentration of sour gas), but also those of which they are unaware?

It is actually difficult to think of a structure against which the corporate memory could be tested as it would need to cover everything. Doing any engineering badly on a high hazard facility may directly create a safety hazard. The closest example might be that of comments made by the HSE or other regulator on a corporation's fitness to manage its risks, perhaps based around ISO 9001 (ref. 11). Another analogy would derive from the engineers of the insurance industry, who assess facilities for both the hazards that resulted from the innate nature of the operations and also the managerial approach being applied, against broad ranging, experience based "Best Practices". Indeed there is a general acceptance of a direct correlation between the quality of the management onsite and the likelihood of accidents, both small and large.

What is regarded as a weakness of the insurance survey system, its brevity, with typically only a few days spent on each site, is an advantage here. Insurance engineers need to be efficient and to target key areas to test whether owners had a good understanding of their duty to get the most possible from the people whom they employed. They therefore focus on quick questions in targeted areas that identify aspects such as: a paper based inspection system that did not project corrosion rates into the future to predict remaining life of pipework, for example, and an electronic system that did. In addition, by asking the same question to the personnel at the generating and receiving end of the information, one could determine if information became knowledge. Measuring the links between different parts of an organisation is a key aspect of demonstrating that knowledge is being passed around and being acted upon.

It has to be said that complete ignorance of a plant is never found on survey. On the other hand, plant operations can be incredibly complex; so much so that even one of the safest sites that the authors visited was heard to say, with some satisfaction: "Now we at last have a flow chart that shows me, for the first time, everything that we produce on this facility!" The site had been in operation for much more than 50 years and covered several square kilometres with processes of every size. It does communicate very well the scale of the problem.

Monitoring Use of Standard Systems

Some basic standard approaches to engineering such as the prescriptive, ISO, NFPA, API and so on, and those of assessment such as QRA and HAZOP can both do a lot to at least provide a common baseline in terms of safety, however, they do little to address the interactions that are such an important part of the "nervous system" of the body. These form a corporate knowledge that is generally accepted across the whole industry.

Understanding of the Need for Efficient Communication

In an organisation where knowledge is key, sharing of that knowledge should also be a very live process. This sharing must also be reduced to manageable levels and a lot of thought should go into presenting the information almost subliminally. Thus visual layouts of worker disposition during hot and cold work on a computer screen, together with pop ups that say what work is being done, will be more easily digested than a folder full of forms or a list of emails. The use of KPIs is another efficient way of reducing the amount of data transfer to manageable levels.

Communicating Live Awareness of System Issues

One the prime features of accident investigations is the confluence of elements of the body corporate who have acted in a way that serves temporary or local needs, whose interdependencies and negative consequences are not recognised at a system level. Examples abound on surveys, too.

Some issues that exemplify the above are:-

- that systems level studies such as HAZOPs and HAZIDs that incorporate preventive and protective measures are not available in a live manner, so that the day-to-day hazard profile of the plant is unavailable to staff;
- that interactions of hazard generating actions such as maintenance and equipment outage need to be visible to staff, so that the geographic interplay of hazards and protection systems is known and controlled;
- that the status of the plant integrity control, which operates on timescales comparable to that of personnel experience of the site, needs to be made available almost with a time lapse type of visualisation.

In order to create a corporate vision of one's plant, there is a need to consider:-

- what information do personnel on site have and how important is it;
- what would it take to put it in a form that everyone who needs to know can access.

In particular with reference to assessments on plant hazards, such a move would create both an artificial nervous system and a brain for a company. As mentioned previously, bow-tie diagrams are a simple and effective tool for communicating risk assessment results to employees at all levels. The diagrams clearly display the links between the potential causes, preventative and mitigating controls and consequences of a major accident. It also is a visually strong way of providing a dashboard for day to day representation of the condition of all systems. Yet surprisingly few organisations have such systems as an operational guide.

A bow tie system also has the potential to be linked to the output of other systems in a live fashion so that the health of systems such as the inspection and maintenance and control and safety systems such as the fire and gas detection or trip systems are all brought together.

Visualisation

Visualisation is nice to have. Wouldn't it be great to be in the control room, to be able to produce a screen that shows the deployment of the workforce on a facility, knowledge of what they are doing, what the condition of the plant is, the availability of detection and other safety systems, the validity of their permits to work?

In fact, when examples are seen of the benefit that visualisation brings, one wonders why every plant does not have it in some form. When one hears of the costs associated with these systems, which are naturally affordable by those who have invested in them, it becomes even more puzzling why they are not much more widespread. We visited one site where the total costs for an emergency management system, including software, were quoted as being €50,000.

The scalability of such systems is also impressive. New knowledge can be added, extending the applicability of the system to new users. The result is that more parts of the organisation are brought into regular contact, so visualisation inherently facilitates corporate communication.

It is again surprising that the new generation of control systems do not venture more into the area of bringing together multifaceted operational information that are of relevance to the process and its integrity, but which do not have the usual instrument information as input. It is believed that this would be an enormously beneficial and efficient way of bringing together wider management information, and even potentially take the control system beyond the control room.

What is the Future for Corporate Knowledge?

It is clear that knowledge retention, learning and transfer are key issues for high hazard industries, whether the installation is changing owners, or simply changing shifts. Yet it is an elusive concept that currently manifests itself most visibly when it is absent. One can have systems of inspection, of authorised outage of key critical safety systems. One can have HAZOPs and QRAs. Corporate knowledge is the awareness that this information needs to be shared and acted upon by the

appropriate parties, to be structured and to be measurable. Without it the facility will operate with a latent weakness, and is more likely to suffer an unfortunate leak or breakdown, or worse.

Its importance as a contributor to industrial upset is exemplified in accident reports for nearly every major accident. These include:-

- Knowledge of the state of the fire water pumps and the compressor relief valve on the Piper Alpha platform;
- Sulfidation corrosion in refinery crude units (Chevron, Richmond, 2012 (ref. 12));
- The Kleen Energy blast in 2010, during a gas blow (ref. 9).

In all cases, the knowledge was there to be used, but there was a demonstrable lack of application.

Despite the repetitive demonstration that knowledge sharing is essential in companies, given that the concept is elusive it is perhaps understandable that formal methods of addressing the issue have not been implemented widely, and that companies might even respond "but we are already doing that!" yet still miss the point.

Measures of corporate knowledge are not the same as measures of departmental knowledge, they are the measures of the application of the knowledge - everywhere it is needed. To digress with one more example:-

> *"There were few indications of any trouble with X before the explosion. [it] won an award from the [authorities] for its safety record, and on the day of the disaster, Y and Z managers were on board to celebrate seven years without a lost-time accident. a Y spokesman, said rigs hired by Y have had better safety records than the industry average for six years running, according to [authorities] statistics that measure the number of citations per inspection." Wall St Journal June 2010 (ref. 13)* .

At the same time:-

> *"In 2008 and 2009, the surveys ranked Z last "job quality" and second to last in 'overall satisfaction'." Wall St Journal June 2010 (ref. 13)* .

This is, of course, a reference to the Deepwater Horizon disaster. Knowledge of issues with cementing wells was available, as was the deteriorating performance of the Transocean rigs (which one would have thought would be a question in the bid review process).

The worrying trend in major hazard accidents is that there is not much evidence that our industries practices are improving, rather the reverse. Of the top 20 incidents in Marsh's compendium of 100 Largest Losses 1972 – 2011 (ref. 14), 9 have occurred since 2000, and that is allowing for inflation of the older losses. One can of course argue that with increased prosperity and development there are more process plants around, thus one would expect more accidents. The counter-argument that corporate knowledge remains weak is that the accidents listed in the document are exactly the same type of accidents that have always been occurring, in some cases, to the same facility!

Thus, corporate knowledge has a stronger case than ever for being on the agenda of developments in safety.

Conclusions

This paper took its inspiration from a passing thought of a refinery manager in Eastern Europe. He raised the issue before 3 of the incidents referenced in this paper had taken place, each of which illustrated to devastating effect exactly the point he was making. 16 people would be alive and billions of dollars of losses could have been avoided if the issue had had the same prominence as other aspects of safety.

Our wish is that assessment of corporate knowledge joins the ranks of other tools used to assess organisational safety. Many of the elements are already in place, however, the communication structure is not, the prioritisation strategy and visualisation aspect are also fruitful areas for development.

An organisation such as the IChemE could play a leading role in the development of a structured toolkit and we would encourage a dialogue within the organisation to put corporate knowledge sharing on a formal footing.

The agenda for such a working group would be to:-

- generate a general best practice document;
- show that Corporate Amnesia is an important a contributor to hazards;
- describe how best practice can be measured;
- recommend efficient communication means;
- outline performance features of systems for cross departmental live visualisation of hazards;
- show how system level risks are monitored;
- show how this concept extends the Safety Case regime to capture hazards that continue to occur.

By doing so, the group would finally provide a structure to this issue and give industry a framework with which to control the problem.

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