PROCESS SAFETY LEADERSHIP, WORKER INVOLVEMENT, LEARNING ORGANISATIONS AND INFORMATION FLOWS†

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A comparison of process safety management practices in the UK and Japan revealed an interesting difference. The UK puts considerable emphasis on leadership, whereas in Japan the focus is on workers to make safety improvements. This difference is explored and a case made that approaching process safety from both top down AND bottom up is best. Initiatives are then discussed in that context. A learning organisation facilitates process safety at all levels in the organisation and a review of how to develop a learning organisation in major hazards is presented. Learning organisations are then discussed using an example involving the process safety information required for safe operation of exothermic reaction processes. A study is introduced involving the systematic analysis of process safety information flows, so as to identify information which can be lost over the lifecycle of a process.

KEYWORDS: safety culture, SMS, exothermic, information flow, major hazards

INTRODUCTION

HSE (2008) suggests that one aspect of leadership in major hazards is to focus on becoming a learning organisation that not only values and encourages learning from its own experiences, but looks beyond itself for lessons, and avoids complacency. The Baker Panel Report (Baker et al., 2007) on their review of BP's US refineries following the Texas City incident stressed the importance of process safety leadership as part of its first recommendation. This typifies the priority which is put on leadership in the West. However, in Japan, it is expected that workers and managers have a high degree of company loyalty and responsibility and therefore seek to do what is best for the company. This means that there is much less focus in Japan on improving leadership to reduce risks from major hazards.

The purpose of this paper is to explore the interaction and relationships between these three approaches to process safety:

- Learning organisations
- Leadership
- Worker involvement/empowerment

LEARNING ORGANISATIONS

WHAT IS A LEARNING ORGANISATION?

Karash (2002) described a learning organisation as one that learns and encourages learning among its people. It promotes the exchange of information between employees hence creating a more knowledgeable workforce. This produces a very flexible organisation where people will accept and adapt to new ideas and changes through a shared vision.

Learning organisations are those where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, collective aspiration is set free, and where people are continually learning to see the whole (Senge, 1990). Not only do the individuals learn but the organisation itself does too. The essence of organisational learning is the organization's ability to use the mental capacity of all its members to create the kind of processes that will improve itself (Dixon, 1999). Pedler et al. (1997) define a learning company as an organisation that facilitates the learning of all its members and consciously transforms itself and its context.

Learning organisations imply a culture of learning which goes beyond formal training. Learning organisations recognise that those individuals closest to processes have the best and most intimate knowledge of their potential and flaws. The learning culture values knowledge and shows a belief in empowerment. "Knowledge mobility" emphasises informal channels and personal contacts over written reporting procedures. Cross disciplinary and multifunction teams, staff rotations and experiential learning are essential components of this informal exchange (Nutley & Davies, 2000). Peer assists (e.g. a meeting/workshop where people external to the group are invited to share their experience and knowledge) and peer review are encouraged (Boyle, 2000).

LEARNING ORGANISATIONS IN MAJOR HAZARDS

The concept of learning organisations was developed as a tool for business management, concerned with productivity and efficiency. Senge et al. (1994) suggested that the organisations that truly excel are those that discover how to tap people's commitment and capacity to learn at all levels of the organisation. It has been applied in a number of organisations including some which operate major hazards processes, such as Shell (Boyle, 2002) and BP (Collison & Parcell, 2004). Other industrial organisations which have benefited from a learning organisation approach include Alcan, Toyota and Motorola (Pemberton (1993), Schweitzer (2005), Wright and Edwards (1998), Liker (2004), Liker and Meier (2005, 2007), Morgan and Liker (2006), Motorola University (1999), Herder et al. (2004), Schoenborn (2006)). In the health sector, the National Health Service (NHS) adopted learning organisation initiatives with the aim of maintaining flexibility and competence in the face of rapid change and profound uncertainty in the organisation's environment (Nutley & Davies, 2000).

British Energy (Beswick & Kettleborough, 2007) in the nuclear sector, have applied learning organisation principles to the improvement of safety culture. The critical activity at the core of the safety culture enhancement programme was the development and roll out of systematic and structured nuclear safety culture workshops to educate all levels of the organisation, followed by activities to encourage and embed a sustained improvement. Based on what has become known as British Energy's four 'Es' model, the enhancement process consists of:

- **Engagement** of each business unit (Power Station or Central Support Function) in the requirements and expectations for the programme roll out .
- **Education** of *all members* of the business unit.
- **Encourage** phase where the business units start to *put into practice the lessons* they have *learned* from the workshops.
- **Embed** phase consisting of *ongoing effectiveness reviews and assessments* to *identify areas for continued improvements and longer term activities to sustain* a strong nuclear safety culture.

A number of other key improvement activities were also implemented. The main areas of continuous improvement that support the enhancement of nuclear safety culture were:

- Development of the corrective action programme, to allow all personnel to raise safety and quality issues, enabling the organisation to address near misses and precursors to safety significant events.
- A formal operational decision making process, to provide a structured and documented process for making and communicating decisions that impact nuclear safety.
- Enhanced focus and resource for staff training.
- A human performance enhancement programme to train leaders in Task observation and coaching and educate the workforce in error prevention tools and techniques.
- Leadership programme to underpin attitudes, behaviours, tools and techniques.
- Equipment reliability programmes.
- System health programmes, both of which are designed to keep the right plant working in the right way at the right times.

Saw et al. (2009) present a toolkit for understanding what a learning organisation is and how to begin to develop one within an organisation. Ways in which the regulator can act as a learning organisation in major hazards are then presented, using HSE's offshore fire, explosion and risk assessment team as an example. These include:

- Learning from experience via inspection, assessment and incident investigation; and also by conducting analysis of the gaps in current knowledge so as to stimulate research and find solutions.
- Sharing ideas and information including feedback to companies following inspection, provision of guidance, and presentation of papers at conferences and seminars.
- Being open to and encouraging innovation including that by the industry to reduce risks and to understand and address the risks from new technology; and innovation within the regulator to improve effectiveness.

No other examples have been found in the literature of the application of learning organisation principles specifically to major hazards safety improvement.

LEADERSHIP AND WORKER INVOLVEMENT

WHY IS LEADERSHIP NEEDED?

Process safety leadership is essential to ensure that the relative priorities of safety and production are understood at all levels in the organisation. Cullen (1990) in his investigation into Piper Alpha stated "They (Senior management) were too easily satisfied that the permit to work system was being operated correctly, relying on the absence of any feedback of problems as indicating that all was well". Leadership, management control and communications were all key areas.

Leadership has to consistently reinforce this message and it is not an easy task. Analysis of responses to the HSL safety climate tool (HSL, 2008) has shown that generally the greater the seniority of a manager the higher their belief that safety is the top priority. Conversely, lower levels of management and operators respond with the belief that the organisation's main priority is production.

Japanese industry has a culture of lifelong employment within the same organisation, leading to the organisation becoming like a family. This promotes considerable worker loyalty and desire to contribute to the good of the organisation. However, even so, this does not necessarily equate to giving priority to process safety, as this may not be perceived to be important to the organisation. There is however a culture of complying with quite prescriptive Japanese safety legislation and this provides some direction towards process safety.

WHY IS WORKER INVOLVEMENT NEEDED?

The implementation of safety features, procedures, maintenance, inspection etc is by the workers who operate and maintain a process plant. This is influenced and facilitated by various levels of management below the organisation's senior management. It is also influenced and facilitated by technical functions within the organisation, including process development, engineering and safety. People in a wide range of roles within the organisation need to take the messages from process safety leadership and apply them in practice.

People at all levels in the organisation also have key skills and information which are required to solve safety problems. It is those who operate a plant or process who really understand operational issues; and those who design and develop the process who understand the more technical issues relevant to safety. Leadership can help to organise, resource and prioritise for safety, but the contribution of people from throughout the organisation remains key.

Motivation to work in a safe way does not necessarily stem from senior management leadership. It would be unusual for anyone to chose to work in a way that they believed was unsafe for themselves or their colleagues, but risk perception is important here. Culture and peer pressure are also important inputs to behaviour. Findings from the industrial application of the safety climate tool reveal that corner cutting and behaving unsafely can affect the organisation. However upon interrogation in focus groups, individuals typically state that it would not affect safety (Sugden et al., 2008). This belief is probably only valid for visible occupational safety issues, and would be harder to justify for process safety issues. For example, individuals may not have an in-depth understanding of the contribution that cutting corners in maintenance or inspection could have in the risk of a major hazard incident occurring; whilst, they would understand the risks to their personal safety of not wearing their PPE.

TOP DOWN AND BOTTOM UP

A good analogy is hazard identification, where it is well accepted that a combination of top down and bottom up studies can be more effective than one or the other and both are usually used at different stages in a project (Crawley & Tyler, 2003). A top down study ensures that causes of envisaged top events (e.g. fire, explosion, toxic release) are considered. A bottom up study such as HAZOP is more detailed and may possibly identify top events that had not been envisaged, as well as further causes of those that had.

In this context "top down" implies leadership as a means of achieving process safety; "bottom up" implies process safety initiated by the workforce. It is evident from the discussion above that the two approaches are complementary and that both are required:

- Direction and motivation from the top to maintain and improve process safety (leadership); and
- Proactive implementation and improvement of process safety at all levels within the organisation (worker involvement and empowerment).

A learning organisation, as described above, has the same attributes of leadership from the top and participation at all levels in the organisation towards learning and improving process safety (see Figure 1).

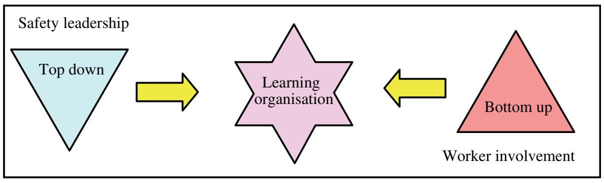

Figure 1. Leadership and worker involvement are attributes of a learning organisation

INFORMATION FLOWS

INFORMATION FLOWS WITHIN A LEARNING ORGANISATION

According to Argyris and Schon (1996) learning organisations need to have organisational structures that allow and channel information, and a culture which facilitates this flow. Hence an essential component of a learning organisation is one that it allows information flows. Below, information flows relevant to an exothermic reaction process are discussed, from the standpoint that if key information is not transmitted, then safety problems could result. First, however, information flows within a learning organisation will be considered in a more generic way.

Figure 2 illustrates that a learning organisation will have information flows internally (sharing) which lead to learning and innovation. It will also have information flows from (learning from external bodies) and to (providing guidance externally) its external environment. Figure 3 illustrates in a very simplified way that there are many entities at different levels inside and outside an organisation which all need to exchange information and learn from each other.

INFORMATION FLOWS FOR AN EXOTHERMIC PROCESS

Figure 4 illustrates the lifecycle of an exothermic reaction process, which includes:

- *Research*: A phase to design a new molecule with beneficial functions and establish a primary synthetic route; it requires chemistry knowledge.

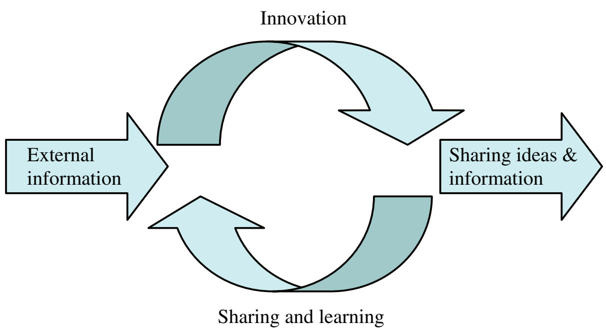

Figure 2. Main types of information flow within a learning organisation

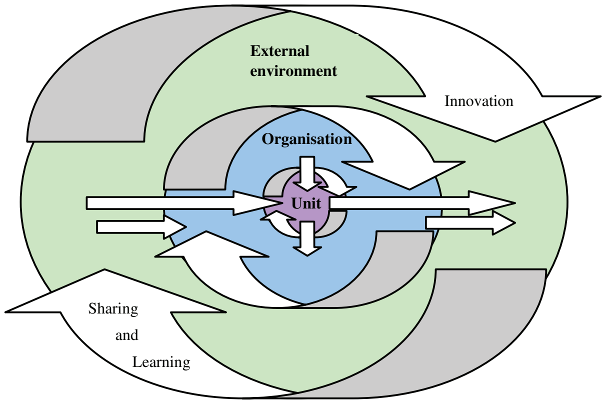

Figure 3. Outline schematic of information flows between different organisational levels and the external environment

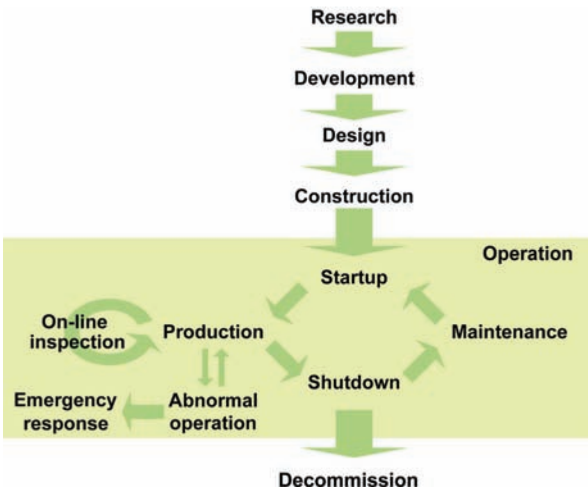

Figure 4. Lifecycle of an exothermic reaction process

- *Development*: A phase to optimise or sophisticate the synthesis process for mass production; it requires chemistry and chemical engineering knowledge.
- *Design*: A phase to design facilities to execute the process; it requires chemical engineering and equipment engineering knowledge.
- *Construction*: A phase to materialize the design; it requires equipment engineering and construction knowledge.
- *Operation*: A phase to operate the facilities and generate main profit. It can include some procedures – start up, production, shutdown, maintenance, on-line inspection, and so forth; it should require the knowledge embedded in the preceding phases.
- *Decommission*: A phase to dismantle the facilities.

There is a large amount of information which needs to be passed on between the phases in the lifecycle of a process. Some examples are given in Table 1. Some of this is critical for safety. Process development involves considering many options for many aspects of the process (see Figure 5).

The model in Figure 4 does not specifically include Commissioning although it is recognised that this is a critical stage for verifying design information and revising forcasted system behaviour/performance (including technology, humans and organisation) prior to operational handover. Information flows during commissioning are therefore particularly important. Lawson (1999) shows that the amount of information hits a peak during commissioning whilst the number of people involved plunges.

There are also information flows required between different functions in the organisation. Figure 6 illustrates some information flows for an organisation which has separate operations/process development and engineering functions. There are many organisational functions, levels in the organisation and stages in the lifecycle which need to maintain information flows in order to achieve safety.

A systematic brainstorming was carried out, at quite a high level, on information flows which are required to achieve safety in an exothermic reaction process. Figures 4–6 were used as a starting point to identify types of information flow and then to brainstorm barriers to that flow, the type of information lost, hazardous consequences and possible mitigation. Team members included chemists and chemical engineers with experience of safety issues in exothermic processes; and human factors specialists. Table 2 summaries some types of barriers to information flow which were identified, together with possible mitigation.

A range of mitigation possibilities was identified in Table 2, including a learning organisation culture. Indeed, few if any barriers to information flows were identified for which a learning organisation culture would not be beneficial; few of the identified mitigation measures would not form part of a learning organisation. However, many of the identified mitigation measures are more tangible than cultural. These include procedures, specific documentation, specific training, control and trip systems, and employment contracts. A learning organisation therefore encompasses and encourages a range of approaches to achieve process safety. It will develop hardware and procedural controls as part of the learning and innovation process. It also instils a culture of learning and openness, which will facilitate safe responses to safety issues which have not yet been recognised and therefore which do not yet have codified solutions.

CONCLUSIONS

This paper has explored what a learning organisation means for process safety/major hazards. A learning organisation encompasses a range of organisation levels and roles from process safety leadership to worker participation.

Information flows necessary in the development, design and operation/maintenance of an exothermic reaction process have been considered in relation to those of a

Table 1. Examples of information produced at different stages in the lifecycle of a process

Stage	Examples of information
Research	By-products, Optimisation processes. Concentration, Scaleability. Catalysts; Viability of chemical route; Is reaction rate related to amount of agitation?
Development	Flow behaviour; Optimisation; Feasible reactions; Kinetics; Yield; Cleaning after reaction; Compatible/incompatible materials; Retrofitting; Environmental consideration; Recoverability; Dispersion characteristics; Legal limits – safe concentrations of release into environment; Gas emissions; Composition time; Toxicity; Water/air reactivity; Cross-contamination; Concentration; Energy requirements; Waste disposal; pH; Catalysis; Business case
Design	Storage of materials; Design pressure; Bunding – capturing releases; Human factors; Interface between people; Control; Staffing levels; Risk assessments; Inherent safety; Labelling; Extraction systems; Indoors or outdoors; Layout; Ergonomics; Draft operating procedures; Safe operating envelope; Compliance with standards; Land Use Planning; Firefighting equipment; Storage, warehousing, transport, packing of product; Location of control room.
Construction	Location of construction village; Control of contractors; Proximity of occupied buildings; Risk assessment; Equipment required; Design specifications/plans; Proximity to operating plant; Prefabricated/built on site; Infrastructure/construction supplies; Transport; Separation and segregation.
Operation	Emergency arrangements; Staff competencies; Safety management systems; Sampling procedures – Real time analysis; Tanker loading/unloading procedures; Lone working issues; Robust labelling; Raw material handling; Identification of leading indicators; Process for fault reporting; Interaction with other plant on site; Ignition sources; Site security; Safety inductions; Personal Protective Equipment (PPE); Start up and shut down procedures; Management of change; Staff training; Permits to work systems; Shift working issues; Quality; Housekeeping; First aiders; Abnormal operations; Noise levels; Understanding of safe operation envelope.
Maintenance	Inspection (risk-based); Up-to-date drawings – should reflect modifications; Purging; Passing information over on shift changeover; Scheduling of maintenance activities; Permit to Work (hot work, welding etc.); PPE; Alarm testing; Risk assessment; Accepting plant back after maintenance; Checking maintenance done correctly; Working on live plant; Training of sub-contractors; Tracking systems; Fault reporting procedures; Managing breakdown maintenance; Hot working/explosive atmospheres; Lifting; Working at heights; Accessibility for maintenance; Separation and segregation.

learning organisation. A learning organisation encompasses and encourages a range of approaches to achieve process safety from cultural to hardware and procedural controls. It would be expected to promote flexibility to deal with new safety issues which do not yet have codified solutions. Information flows during commissioning is likely to be a fruitful area for future work.

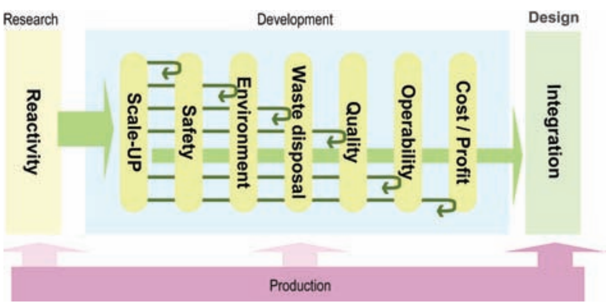

Figure 5. Illustration of how information can fail to be passed forward

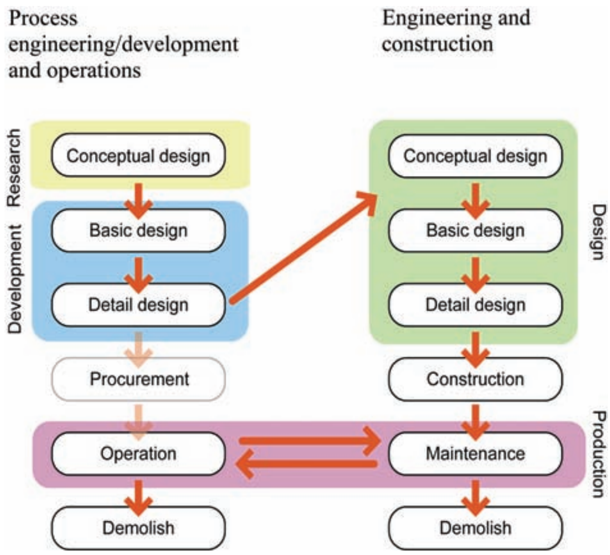

Figure 6. Illustration of some information flows between operations and engineering

Table 2. Barriers to information flow and possible mitigation

Barrier to information flow	Possible mitigation
Physical locations of process developers and design team	Hazard studies – HAZOP Process developers comment on engineering design Co-locate design team
Different backgrounds and mental models (translation issue, identifying what is important)	Include person with an interface role Short-term secondment into other discipline Teaching each discipline an appreciation of the other
Design people from early on in the process may not be involved in later stages – lack of continuity	Trying to ensure continuity – keep at least one staff member Knowledge/repository of information Writing safety case at each stage Good documentation
Too much information	Information repository Creating learning organisation culture where people want to know background Involve operations staff in deciding what information matters Have a structured process – a project team with continuity in it Need for an 'intelligent' customer
The wrong people at HAZID meetings	Learning organisation Specify who attends meetings and signs things off Ensure information cascaded Checklists of documentation Involve people from all levels
Having too many high level staff – no practitioners	Get right people to meetings, have a mix of people Need mechanism for involving people
Ageing workforce – retirement	Knowledge harvesting Succession planning and training Awareness of what might be important in the future Issue logs/risk registers – having a quality plan
No system of communication with maintenance function	Having a system-improving system Train operations staff in how maintenance is prioritised Prioritising resourcing
No communication of need for maintenance because of need not to stop production	Development of a safety culture Process safety leadership Have understanding of cost of repair after incident/breakdown – this will help when showing importance of maintenance Culture of trust between maintenance and operations
Contract maintenance – having blame culture	Good interface Partnership working Good vetting of contractors Effective contract Contractors integrated into company structure
Not feeding back when maintenance finished	Permit to Work Culture of trust between maintenance and operations
Holding onto information for job security	Culture of being open Learning organisation culture Incentives for not holding onto information Rewards for teams, not individuals
Management of change – lack of documentation for design of current plant Not valuing management of change procedures	Documentation – keep it for the life of the plant Risk assessment Training Making management of change process fit for purpose otherwise procedure not used

(*Continued*)

Table 2. Continued

Barrier to information flow	Possible mitigation
Need to prioritise information so operators aren't overwhelmed	Documentation Design control and trip systems wider than envisaged envelope Troubleshooting guide with most important information on how to deal with unsafe situation
Staff turnover	Rewarding success Try to get replacement – handover period Employment conditions/notice period Having more than one person for each role
System is too prescriptive – sticking to set procedures, not thinking beyond them	Retraining Valuing those who think outside the box Empowering people to improvise within limits

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