Effective Safety Management in Hazardous Environments

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International Leadership Speaker Jim Bennett explores the area of Human Factors in Major Accident prevention and effective safety management in hazardous environments. Many organisations are very good at understanding the technical causes of major accidents but struggle to gain a deeper understanding of why the people involved behaved as they did, he suggests that a deeper understanding of an organisation's safety maturity is a core indicator of their safety management effectiveness and gives a good insight on how it influences Safety Leadership behaviours. In particular, hazard and risk understanding from Board Level to the individual at the workface 'decision-making moment.' He recommends a 4-tier approach that dovetails with international Health, Safety and Environmental Management Systems.

Background: recent history ([1] Texas City, Jaipur, Buncefield, Macondo) would suggest that we are not fully prepared for preventing and mitigating major accident EVENTS.
Human Factors (HF) is the 'golden thread' that runs through integrated business management systems. Studies have shown that a high percentage of major accidents are attributable in some degree to human failures. This includes 'technical failures' that have a human error root cause.
Human Factors is defined as: '*Environmental, organisational and job factors and human and individual characteristics which influence behaviour in a way which can affect health and safety.'*

The Essential Collection

Human Factors Principle Components [2]: there are 4 principle components to consider when examining HF in a business that are mutually supporting and not necessarily exclusive to each other:

1. **The Job (what):** Task, workload, environment, display and controls, procedures…
2. **The Individual (who):** knowledge, skills aptitude, behaviour, risk perception ….
3. **The Organisation (how):** Leadership, culture, resources, work patterns, communications…
4. **The Culture and Working Environment (where):** National, Sector and local workplace cultures, social and community values, country economics, legislative framework….

This needs to be considered within the life-cycle business approach of PLAN, DO, MEASURE, LEARN which leads to the continuous learning cycle that is the foundation of International Safety, Environmental and Quality Management Systems.[3]

Mission (Purpose), Vision: *From a business perspective one must also determine the organisation's purpose. What is its long term Vision? What are the business/safety critical systems to deliver it? Human Factors are integral to deliver world-class business performance. e.g.*
Bristol- Myers Squibb (Pharmaceutical Sector) Vision: "We pledge to our patients and customers, to our employees and partners, to our shareholders and neighbours, and to the world we serve – to act on our belief that the priceless ingredient of every product is the honour and integrity of its maker." Mission: to Extend and Enhance Human Life.

Major Hazards

Typically we examine the hazardous components of an organisation and determine their potential for major accidents by identifying their "Top/Initiating Events". Qualitative and quantitative tools are used to develop risk reduction strategies to reduce the risks to As Low As Reasonably Practicable (ALARP) [3]*. Experience has shown that key to risk reduction and major accident control is the field of Human Factors. A core component is the safety maturity of the organisations involved.*

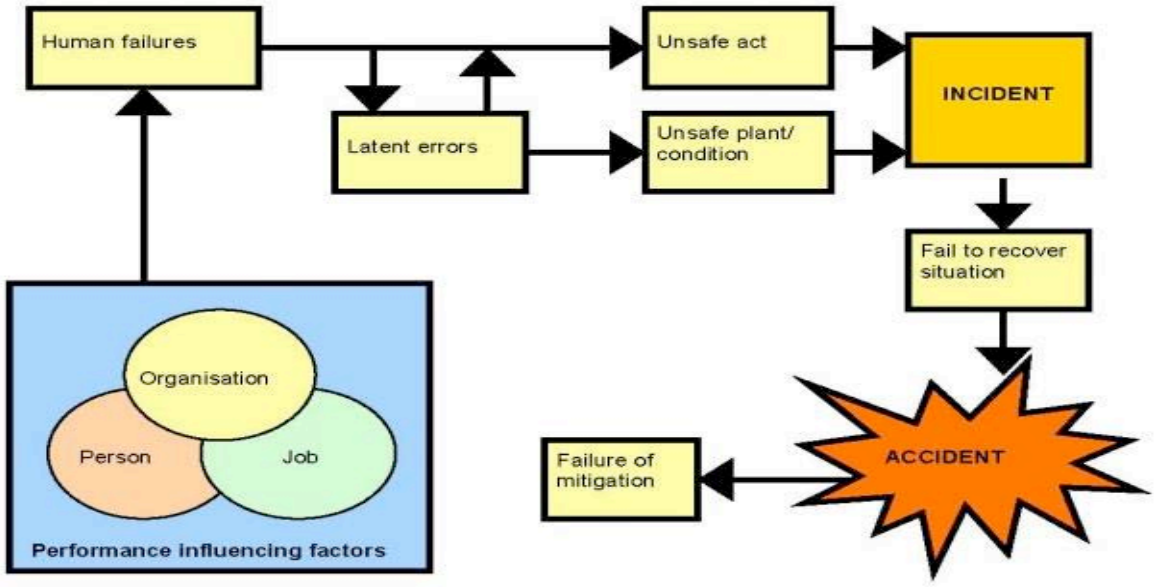
Principle Human Factors Arrangements [4] *include:*
Competence assurance; Identification of human failure; Reliability and usability of procedures; Human Factors in accident investigation

Common Topics *at most sites: Safety Culture, Management of Change, Safety Critical Communications, Maintenance Errors and Emergency response,.*
Important HF issues *for some sites can include: Alarm handling and control room design, Managing fatigue risks, Organisational change and transition management.*
Integrity Management, *which can be summarised as "People, Process, Plant and Performance", is key to the operation of a safe site. Good HF arrangements providing the dynamic barriers and escalation controls: the Safety Critical Elements preventing* the undesired hazard event occurring – e.g. the release of hydrocarbons under pressure.

Barriers include: Safety Leadership, Engineering Design, Risk Management, Competency, Procedures and Practices, Inspection and Maintenance, Management of Change, Control/Instrumentation.
Escalation Controls: Detection/Control, Emergency Response, Accident Investigation, Audit/Review.

Human Failures

There are three principle types of human failures (unsafe acts) that can lead major accidents:



Unintentional errors:

1. **Slips/lapses** that are "actions that were not as planned" (unintended actions). These can occur during a familiar task e.g. omissions like forgetting to do something, which is particularly relevant to repair, maintenance, calibration or testing. These are unlikely to be eliminated by training and need to be designed out.
2. **Mistakes** are also errors, but errors of judgement or decision-making ("intended actions that are wrong") where decisions are formed from first principles and lead to misdiagnoses or miscalculations.

The aviation industry has developed a methodology for understanding human information processing which was developed by Wickens[5] – it has been used in the offshore oil and gas sector. It describes the four stages of human information processing and performance, namely: perception, memory, decision-making and action. A human error can call result of a failure in any of these four stages.

Intentional errors

3. **Violations** differ from the above in that they are intentional (but usually well-meaning) failures, such as taking a short-cut or non-compliance with procedures e.g. deliberate deviations from the rules or procedures. They are rarely wilful (e.g. sabotage) and usually result from an intention to get the job done despite the consequences. Violations may be situational, routine, exceptional or malicious.

Human Factors Research and Development

Considerable research[6] has been carried out within the United Kingdom onshore and offshore oil and gas sectors – this is worthy of study to get a fuller understanding on the depth and breadth on its impact on the management of Major Accident Hazards.

ORGANISATIONAL SAFETY MATURITY

At the root of major accidents prevention and control is the organisational safety maturity of Major Hazard sites. The Energy Sector has developed a pragmatic model [7] that allows a qualitative assessment of an organisation's safety maturity. This model has been used for circa 20 years and is available in 12 languages. Benchmarking has shown that more mature organisations are proactive and have a holistic approach to Hazard Management which includes integrated leading and lagging performance indicators within a continuous learning culture that is consistent with international HSE Management Systems.

Less mature organisations being *Reactive* to situations – using 'rules and regulations' to manage their business. A "middle ground" is organisations that have basic systems in place (*Calculative*) and react to emerging risks. *Proactive* organisations having a greater level of competence – being more skilful and utilising leading performance indicators to enhance their safety. Continuous Learning organisations (*Generative*) use 'knowledge' to generate solutions and are dynamic in nature with strong Safety Leadership at all levels in an interdependent environment.

Safety Leadership

Human Factors is the 'golden thread' that runs through business management systems. A key component is Safety Leadership that greatly influences the safety culture and its maturity. Leadership that is Agile, Open and Trustworthy is typical within 'Generative' organisations. In these organisations there is a strong hazard and risk management knowledge with clearly defined and understood responsibilities as detailed in the following Table. This allows for greater organisational resilience and dynamic risk management.

LEVEL	TYPICAL INDIVIDUALS	HAZARD AND RISK MANAGEMENT KNOWLEDGE *(these are not specific to the individuals listed in the preceding column)*	TYPICAL RESPONSIBILITITES *(these are not specific to the individuals and knowledge in the preceding columns)*
LEVEL 1 **Senior Management**	• Board Directors • Engineering Directors • Project Directors • HSE Governance Board	o Overall corporate risk levels both individual and societal o Comparative risk with similar and other industries o Spread of risk by the type of business and location o Change of risk patterns as the business develops o Underlying risk drivers such as the age of the facilities, geographical and political influences, business change o Public perception of risks relating to the company business o Risk from future growth options	❖ To set the overall standards for tolerable risk and the investment levels to reduce that risk ❖ To manage the company in the knowledge of the risks ❖ To set overall company targets which can realistically be achieved ❖ To decide if specific businesses or facilities have intolerable risks which cannot practically be reduced and to close them down ❖ To provide the resources and infrastructure to support the business units in their management of risk ❖ To manage the future risk exposure of the company

LEVEL 2 **Local Management**	• Business unit managers • Operations • Project managers • Departmental managers e.g. contracts, procurement, engineering, integrity management, HSE	○ Business and facility risk levels ○ Spread of risk by facility ○ Spread of risk by hazard or activity ○ Spread of risk by types of personnel ○ Risks from future development options ○ Critical areas of ignorance and uncertainty ○ Overall and specific dependence upon business processes such as integrity management, competence and emergency response ○ Dependence on others; major contractors, corporate support,	❖ To manage the operations in the knowledge of the hazards and risks ❖ To determine and implement the risk management strategy for each facility and major hazard ❖ To set the priorities and determine the extent of risk reduction required to meet corporate standards ❖ To shut down plants or limit activities if the operational risks exceed tolerable levels ❖ To select safer concepts where the risks can be effectively managed within corporate limits ❖ To optimise inherent safety and put in place effective hazard management on new designs ❖ To provide local business processes and infrastructure to ensure competent people and plant integrity ❖ To provide sufficient resources for operations and support services

LEVEL 3 **Supervisors and Technical Authorities**	• Installation/Site Managers • Plant managers and supervisors • Discipline engineers • Internal contract managers • External contract managers	o Hazards on the facility and the relative risks o Overall characteristics of each of the major accident hazards; primary causes, severity, immediate consequences, potential and timing for escalation o Hazard management strategy and the critical measures to prevent, detect, control, mitigate and evacuate o The processes and people that ensure these measures are effective	❖ To operate the plant within clearly defined safe limits ❖ To manage the hazards in line with the selected strategy and prioritise work in recognition of their relative risks ❖ To control hazardous activities which may cause or exacerbate major accident hazards ❖ To ensure that the critical measures are suitable and effective through setting and meeting performance standards
LEVEL 4 **Individual**	• Designers and draughtsmen • Plant operators • Maintenance technicians • Contractors	o To understand the hazards associated with their work o To know which procedures and plant are critical o To know the performance standards and limitations of critical plant	❖ To comply with critical operating procedures ❖ To maintain and work within their competence ❖ To design the plant to meet the performance standards for its working life ❖ To maintain the plant to the performance standards

Hazard Management – A Holistic Approach:

Research has shown that a holistic "*Generative*" approach to hazard management is consistent with high performance organisations. It integrates with the five steps from the classical HSE Management Systems described in ISO 14001 and OHSAS 18001[8]:

Policy – Plan – Implement – Monitor – Review

The international standards have a cycle of continuous improvement aiming to progressively elevate standards and reduce risks, both in design and operations. An overview of each of these steps, with respect to engineers and major hazards, is given below with more detailed requirements outlined in the following Major Accident Hazard Management Table based on ISO 14001 and OHSAS 18001.

Policy:

This should be a clear statement of the company minimum standards, its attitude to HSE, the tolerable risk criteria and the way in which it sets about doing business. There should be a structure to corporate policy rather than a series of individual initiatives. This model suggests that policies could be set relating to the four levels of responsibility.

Planning:

This is the core of the risk management process – having two distinct components:

1. The determination of the hazard management strategies, systems and performance requirements;
2. The assessment of the resources needed to implement these decisions during the design and the operations lifecycle.

Implementation:

Hazard management depends on the four Ps – People, Plant, Processes and Performance. It cannot be a stand-alone process as it affects most activities and virtually every item of equipment. It must rely upon the existing business infrastructure of design, integrity management, operational controls, competence, contracts, procurement and emergency response. The planning will identify who and what is critical and the performance standards that they must meet. These will be managed by embedding these requirements into the aforementioned processes. Many of these requirements, up to 90%, will already exist through default design standards, systems and procedures. The planning will confirm if these default systems and performance standards are correct, improve them or add extra features and controls. The planning will also provide an overview of the relative importance of all measures to control risk allowing an overall prioritisation of resources.

Monitoring:

Measurement is becoming an increasingly dominant part of business and regulatory life. There is a temptation to focus on those items against which measurable criteria can be set, mainly the performance of plant and safety systems. This only deals with the lowest level described above. There is also great interest in lagging indicators such as occupational accidents, lost time injuries (LTIs) or equipment failures. Measurement needs to take a broader view, examining leading indicators such as hazard understanding

amongst the workforce or the quality and completeness of the hazard management process.

Review:

Every organisation should strive to improve. The review should determine where, and how much, further improvement is needed. It may be triggered by incidents within or beyond the organisation, or else by trends or failures highlighted by the monitoring. It must take a strategic view and avoid a knee jerk. Learning lessons from incidents is imperative but these may not be a predominant risk within the organisation and should not distort the corporate focus. Classical risk reduction improvements for major hazards are based on measures that can make a quantifiable reduction in individual or societal risk numbers. These tend only to focus on additional hardware, particularly that which reduces consequences. Again, a broader view needs to be taken. Improvement can focus in three areas:

1. The improvement of the infrastructure, resourcing and the quality of the whole hazard management process.
2. A strategic examination of the management of risk and hazard, using the flowchart in Fig 1. It would focus preferentially upon the hazards that contribute the greatest proportion of the risk. Thereafter, it would revisit the hazard management questions of standards, systems and strategy to see where further risk reduction is most appropriate.
3. Organisational safety maturity - in particular, the field of Human Factors that underpins critical activities.

Using this approach, systematic improvement can be applied to each of the four levels of an organisation.

Regulation:

Regulation can promote this approach to risk and hazard management, or it can undermine it. A purely prescriptive regime in which all safety and integrity requirements are defined by law has been proved to be inadequate. The Piper Alpha Inquiry recommended a change from this type of regime as did many others. In the UK and Europe, the Safety Case was the logical successor. It argued that a case for safety should be made and accepted by the regulator. It is undoubtedly a much better approach but experience from the North Sea indicates that there is still scope for improvement if the greatest risk reduction is to be achieved for the investment.

The regulations in themselves might be satisfactory but their implementation should encourage a much more structured approach to managing hazards similar to that described in this paper. The regulators place a considerable emphasis on the numerical quantification of tolerable risk levels and the subsequent demonstration that risks are “As Low As Reasonably Practical”. This has placed great emphasis on these additional measures while, at times, leaving the basics of safety such as competence, integrity management, adequate resourcing and organisational safety cultural maturity in the background.

Some of the rigour that existed in the prescriptive era seems to have been lost and it should be reinstated. The regulatory framework now calls for a clear linkage between the hazards, these critical systems and their performance. The regulations also press for explicit presentation of hazards and risks, and associated responsibilities as outlined in the Safety Leadership Hazard and Risk Management Table above.

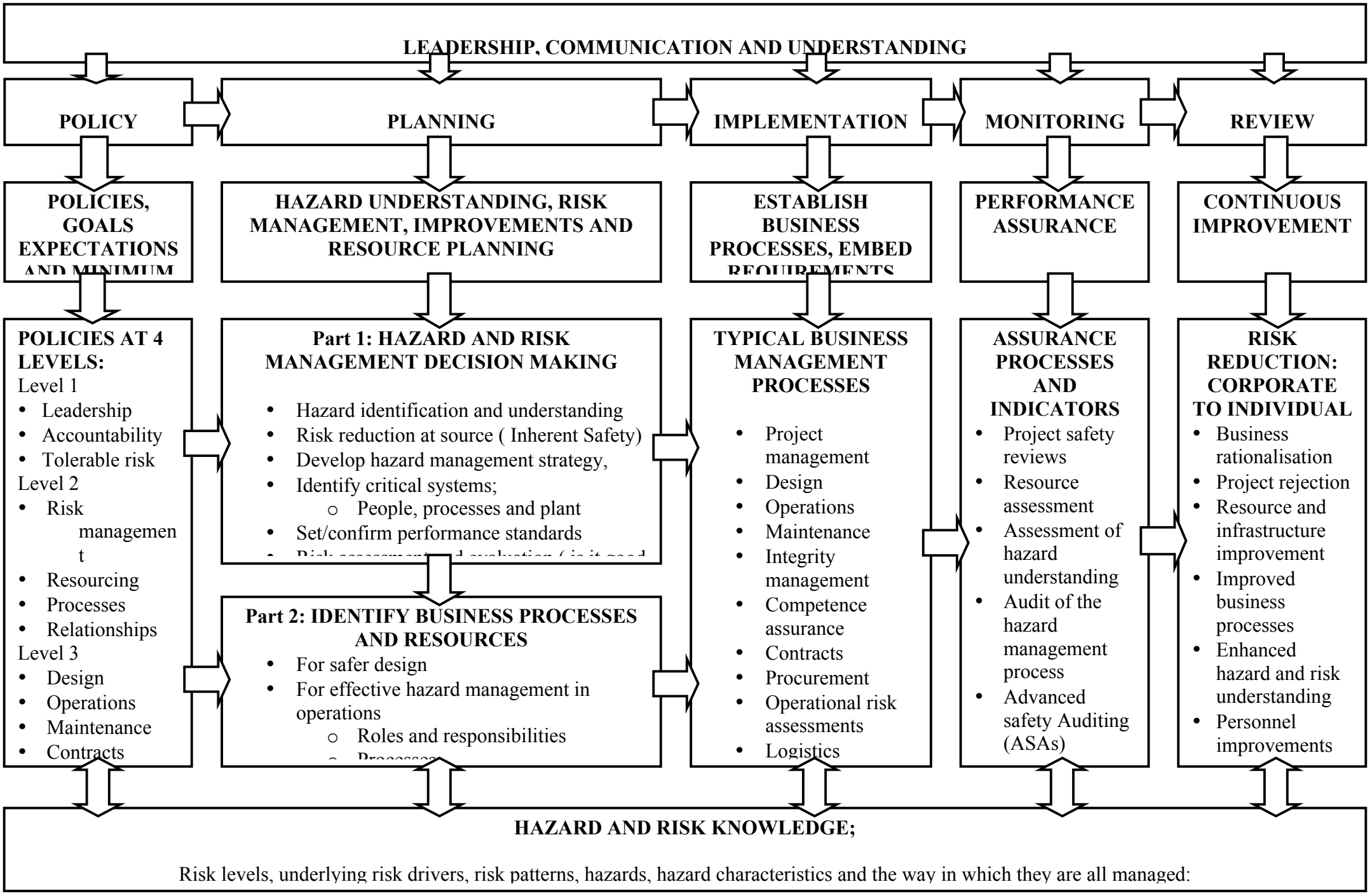
From a major accident hazard prospective experience has shown that it is preferable to use a Major Accident Topic Principal [9] to reduce risks to a tolerable level.

Examples of 'topics' worthy of consideration include:

- Loss of Structural Integrity – for example (e. g.)
  - Fixed steel structures
  - Extreme weather
  - Corrosion
  - Seismic event
  - Operator error
  - Inadequate inspection, prepare, and maintenance
- Loss of Containment – Process e.g.
  - High-pressure vessels
  - Pipelines
  - Relief systems
  - Valves and pumps
  - Compressors
  - Hazardous drains
- Loss of Containment – Fire and Explosion e.g.
  - Ignition probability
  - Escalation, layout, separation
  - Fire types and modelling
  - Hazardous area zoning
  - Explosion modelling
  - Deluge and sprinklers
- Non Process Fires and Explosion e.g
  - Accommodation fires
  - Electrical fires
  - Cellulosic frire
- Emergency Response e.g
  - Emergency response management
  - alarms and communication
  - Temporary refuge an muster areas
  - Evacuation
  - Emergency communications
- Human Factors e.g.
  - Human error – selection, competence and training
  - Human error – stress, fatigue, shifts and organisational factors
  - Permit to work systems, procedural integrity
  - Organisational change management

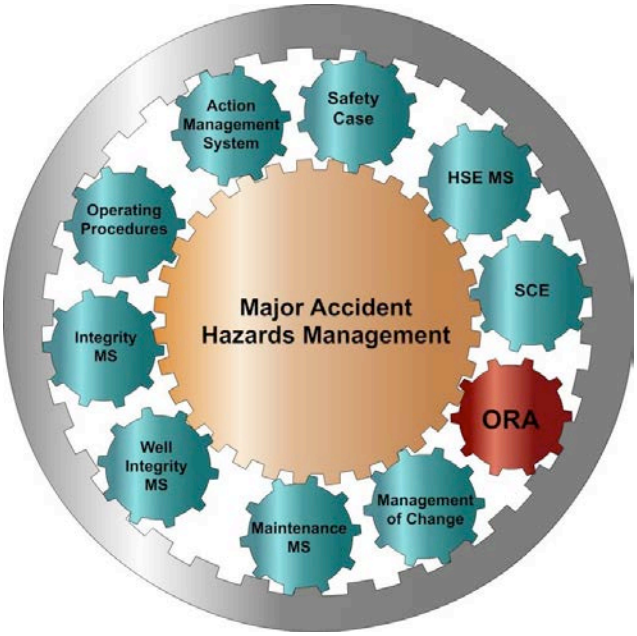
It is through the knowledge and understanding of dangers at all organisational levels within companies that our plants and communities are protected.

In particular, having a structured systems based on proven international standards. The following diagram depicts a 'life-cycle' approach to Major Accident Hazard Management based on ISO 14001Environmental Management and OHSAS 18001 Occupational Health, Safety and Security.


LEADERSHIP, COMMUNICATION AND UNDERSTANDING
POLICY
PLANNING
IMPLEMENTATION
MONITORING
REVIEW
POLICIES, GOALS EXPECTATIONS AND MINIMUM
HAZARD UNDERSTANDING, RISK MANAGEMENT, IMPROVEMENTS AND RESOURCE PLANNING
ESTABLISH BUSINESS PROCESSES, EMBED REQUIREMENTS
PERFORMANCE ASSURANCE
CONTINUOUS IMPROVEMENT
POLICIES AT 4 LEVELS:
Level 1
• Leadership
• Accountability
• Tolerable risk
Level 2
• Risk management
• Resourcing
• Processes
• Relationships
Level 3
• Design
• Operations
• Maintenance
• Contracts
Part 1: HAZARD AND RISK MANAGEMENT DECISION MAKING
• Hazard identification and understanding
• Risk reduction at source (Inherent Safety)
• Develop hazard management strategy,
• Identify critical systems;
o People, processes and plant
• Set/confirm performance standards
Part 2: IDENTIFY BUSINESS PROCESSES AND RESOURCES
• For safer design
• For effective hazard management in operations
o Roles and responsibilities
TYPICAL BUSINESS MANAGEMENT PROCESSES
• Project management
• Design
• Operations
• Maintenance
• Integrity management
• Competence assurance
• Contracts
• Procurement
• Operational risk assessments
• Logistics
ASSURANCE PROCESSES AND INDICATORS
• Project safety reviews
• Resource assessment
• Assessment of hazard understanding
• Audit of the hazard management process
• Advanced safety Auditing (ASAs)
RISK REDUCTION: CORPORATE TO INDIVIDUAL
• Business rationalisation
• Project rejection
• Resource and infrastructure improvement
• Improved business processes
• Enhanced hazard and risk understanding
• Personnel improvements
HAZARD AND RISK KNOWLEDGE;
Risk levels, underlying risk drivers, risk patterns, hazards, hazard characteristics and the way in which they are all managed:

Operational Risk Assessment (ORA) [10]
The Deepwater Horizon disaster has highlighted the importance of having robust and dynamic management systems to manage Major Accident Hazards (MAH).

The Oil & Gas UK have developed pragmatic guidance in order to help organisations implement and maintain agile operational risk assessment procedures to manage MAHs where impairment of a safety-critical element (including loss or degradation of a safety-critical component forming a significant part of an Safety Critical Element) or some other abnormal operational situation may potentially compromise safety and increase major accident risk levels.



Operational risk assessment is one element of a wider suite of integrated management system elements, processes and practices in place to manage major accident hazards.

As an example of interdependence, impaired Safety Critical Elements may be revealed by integrity management activities and remediation of the impairment will become part of the maintenance management or action management systems. This figure illustrates those wider system elements and their interrelationship:

- Safety Case
- Health, Safety, Environmental Management System (HSE MS)
- Safety Critical Elements (SCE) e.g. Pressure Containment,
- Operational Risk Assessment (ORA)
- Management of Change
- Well Integrity Management System (MS)
- Integrity Management System (MS)
- Operating Procedures
- Action Management System

A Holistic approach to Major Accident prevention, with a sound knowledge of Human performance-influencing factors, is required for 21st century corporate socially responsible organisations.

Conclusions

- ✓ The open communication and discussion of dangers, hazards and risks must not be inadvertently suppressed by regulation or the fear of litigation.
- ✓ The understanding of hazards, cause, severity, and consequence is the most powerful means of reducing risk. Organisations must have an underlying ethos that delivers this knowledge. Understanding the links to their management systems – regarding it as essential for the safe design and operation of all facilities.
- ✓ Risk assessments must distil and deliver appropriate information to each part and level of an organisation. Delivering the overall risk and underlying risk drivers to the directors - including delivering specific performance requirements for procedures and plant to the individual at the workplace. This must be used to define responsibilities at every level.
- ✓ Risk assessments must not be a one off specialist activity. They must be owned by those responsible for the risks, undertaken in conjunction with those faced with them and be a living process which is at the forefront of daily and strategic activity
- ✓ All staff in Major Accident Hazard sites should be able to apply a structured approach to risk assessment without reference to guidelines or specialised techniques such as QRA. These should be there to support the development of a complete picture but should not determine the content or how it is painted.
- ✓ Major Hazard Organisations require mature safety cultures, with greater agility, for our dynamic 21st century – requiring a strong co-creative Safety Leadership from Board to workface.

"The sum total and quality of our individual actions will determine whether the men and women on our installations will live or die."

Brian Appleton, Piper Alpha[11] Enquiry.

Bibliography:

1. Buncefield Investigation, 2008, http://www.buncefieldinvestigation.gov.uk/index.htm ; Texas City Baker Panel Report, 2007, http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/SP/STAGING/local_assets/assets/pdfs/Baker_panel_report.pdf Lessons from Longford: the Esso Gas Plant Explosion Andrew Hopkins, CCH Australia Ltd, 2000, ISBN 1 86468 422 4;
2. Human Factors Principle Components, http://www.hse.gov.uk/humanfactors/introduction.htm
3. ALARP – As Low As Reasonably Practicable Guidance http://www.hse.gov.uk/risk/theory/alarpglance.htm
4. Principle Human Factors Arrangements, http://www.hse.gov.uk/humanfactors/toolkit.htm
5. Flight to the Future: Human Factors in Air Traffic Control, Christopher D. Wickens, Anne S. Mavor, 1997, ISBN-10: 0309056373
6. Catalogue of OSD and HID Offshore Research by Key Human Factors Elements, http://www.hse.gov.uk/research/misc/catalnov02.pdf
7. The Energy Sector 'Hearts and Minds', Understanding your Culture, http://www.energyinst.org.uk/heartsandminds/culture.cfm#intro
8. BS OHSAS 18001: Occupational Health and Safety Management http://en.wikipedia.org/wiki/OHSAS_18001 , ISO 9001:2000 Quality Management System http://en.wikipedia.org/wiki/ISO_9000 , ISO 14001:2004 Environmental Management System. http://en.wikipedia.org/wiki/ISO_14000
9. Guidance for the Topic Assessment of the Major Accident Hazard Aspects of Safety Cases, http://www.hse.gov.uk/offshore/gascet/gascet.pdf
10. Oil and Gas UK, Guidance on the Conduct and Management of Operational Risk Assessment http://www.oilandgasuk.co.uk/cmsfiles/modules/publications/pdfs/HS071.pdf
11. Piper Alpha Lessons Learned http://www.healthandsafetyatwork.com/hsw/piper-alpha-lessons