RISK-BASED SAFETY MANAGEMENT AUDITING

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The Offshore Safety Division (OSD) of the Health and Safety Executive has developed an audit technique to assess the effectiveness of senior management in controlling operational risks. It is of necessity a free-format, non-mechanistic approach. The yardstick for management effectiveness is a clear and coherent linkage between the decision makers and the safety realities at the worksite. Included are examples of both strong and weak management of safety, which demonstrate the added value which this technique brings both to OSD and to industry.

Key Words: Audit; Risk; Safety Management Systems; SMS; Senior Management.

"The top men in Occidental were not hard-nosed and uncaring people interested only in profit and unconcerned about safety. They said and believed all the right things, (but) they did not get involved in the precise actions required, see that they were carried out and monitor progress."
- Lord Cullen, from the Piper Alpha Public Enquiry.

INTRODUCTION

The Offshore Safety Division (OSD) of the Health and Safety Executive has over the past three years conducted some 20 corporate level audits of the safety management systems of offshore production operators and owners of drilling installations and contractors. The audits have the broad aim of assessing the effectiveness of management systems for identifying and controlling risks and influencing the auditees to improve their health and safety performance. The audits also assist in assessing compliance with the Offshore Installations (Safety Case) Regulations 1992, Regulation 8 of which requires the operator to have an adequate management system and to have its own adequate arrangements for audit. In short, OSD uses the technique of audit to influence a company on a broad front towards better control of risk.

Our aim in auditing is to answer questions such as:

Are the people on this/these installations safe - or as safe as they reasonably can be?
Are there shortcomings in the systems for the management of Health & Safety?
Are the management systems likely to be robust over the medium term?
Are senior managers effective in controlling risk?

And our aim in influencing is to stimulate senior managers to answer these questions for themselves.

ARE SENIOR MANAGERS EFFECTIVE IN CONTROLLING RISK?

In auditing, our focus is firmly on senior managers as the major influence on risks to persons. This paper does not seek to prove this assertion. I would simply refer you to the Public Enquiry reports into Piper Alpha, King's Cross, Hickson and Welch, The Herald of Free Enterprise etc.

It will be useful from the outset to determine what we mean here by risk. We mean the practical likelihood of a specified hazard being realised given the actual workplace practices, management priorities, constraints and pressures. In other words we mean risk to people on installations coming under the control of the dutyholder. It is not easy to evaluate how senior management control risk so we need to look for links between senior management behaviour and safety critical activities at the worksite. Qualitative and Quantitative risk assessment can help prioritise the scope of an audit but their lack of precision available requires that the audit covers a number of diverse management systems which control these critical activities. These management systems must be thoroughly examined using a carefully constructed framework in order that the effectiveness of senior management may be evaluated through the synthesis of diverse audit findings.

THE ANATOMY OF A SAFETY MANAGEMENT SYSTEM

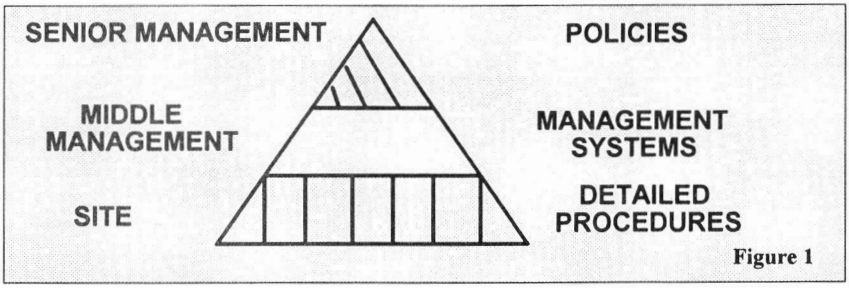

Figure 1

In this simple schematic of a management system (Fig, 1) we see a gradation from the detailed procedures of the technicians and their immediate supervision at the worksite through the broad objectives and management systems in the middle to the strategic overview of the senior management. The concept of this graduation is core to our audit technique - if we are to influence senior management, we must understand the level at which they operate.

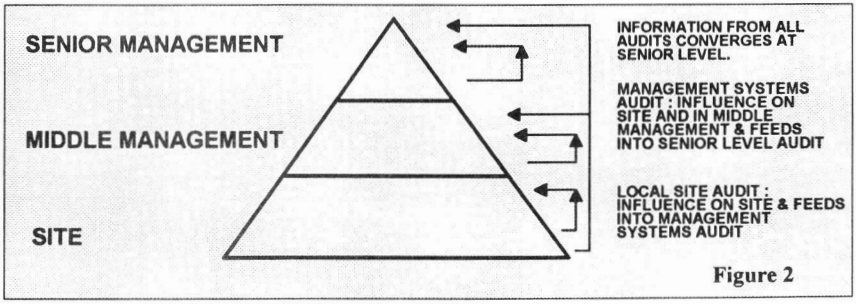

Figure 2

If we audit on site, we can influence the local management. In the offshore industry this would be the first line supervision and installation management up to the Offshore Installation Manager (OIM). If we audit the management systems, we can influence the people who both devise and implement the systems. In the offshore industry these would be the onshore support functions and line management. Since these are also the people with line responsibility for local site management, we can also indirectly influence what happens on site. For example: If our site audit identifies a failure to comply with the permit to work system, then this can be sorted out at a local level. However, if the reason that the permit to work system was not being followed is because site personnel have not had training, then there is an issue for the middle management level too. If senior management cut the training budget last year and re-organised the middle level so that the training department was disbanded and line management have had to pick up the threads (unsuccessfully) then there is an issue for the senior management to address.

BASIC PRINCIPLES OF RISK-BASED AUDITING

Above, we described a management hierarchy and showed how, in the ideal, this is mirrored in the safety management system. As we illustrated through the permit to work example, each level of management can have a role to play in controlling site risks, but each has a unique nature, becoming less and less prescribed as we reach the top of the organisation. Our intent in auditing is not to forge a company into a mythical model of an ideal system but is to test out the worth of the given management structure and systems and determine how effectively it controls risk. We can therefore extract the principle:

The audit process must be compatible with each level of management.

The following features of good health & safety management practice offer additional principles for risk-based auditing. Accepting that health & safety is a line management responsibility it would seem appropriate to seek evidence of control from the line management. It is widely quoted that over 80% (Reference 7) of accidents are caused by human behaviour and for this reason the emphasis should lie on what people actually do and not necessarily upon written procedures or written demonstration of actions. Experience shows that behaviour in an organisation is greatly influenced by the people at the top. Therefore the auditor, in asking why things are as they are, should always look for influences deriving from the behaviour of top management.

Audit those with control over the risks - line management

Audit what people do, as well as what they write

Look for influences on management behaviour

AUDIT METHODOLOGY

In the remaining sections of this paper we describe how these principles are applied in an audit of a multi-national offshore company which operates a number of major hazard installations in the North Sea - it could equally well be an onshore major hazard site. And as we do we will develop the audit methodology by considering the company risk profile and a framework model for management within the company. A 'case study' which contains material collected during such an audit is used to describe how conclusions are drawn from findings collected during the audit.

Primarily in the audit we seek the answer to the question;

Are senior management in control of risk?

To find the answer, first of all we need to identify the principal risks to persons and plant. With minimal knowledge of the detail, and by reference to the safety case, the key risk areas (tabled below) emerge and from them audit priorities can be derived.

The audit priorities are determined by consideration of the main risk contributors on the installation. These may be determined by qualitative means, supported by hard evidence, where they are obvious, and sometimes by quantification. Since human shortcomings are the cause of many accidents, for an operations audit the focus is on people and software systems, not design factors. This in part assumes that the hardware design specialists and hazard assessment teams have already played their part. Equipment is only examined where it contributes to the investigation of a management system. To illustrate, a design assessment may well use QRA to determine which joints in which pipework present the greatest risk of a hydrocarbon emission. We would, in the audit, expect these joints to be in good condition and that maintenance standards and records would be exemplary.

Risk Area	Audit Options and **Priorities**
Well-operations	Design **Maintenance** **Drilling practices**
Oil and gas production.	**Operations** Design
Hardware integrity	**Maintenance**
Wind and weather effects on structure	Design **Operation (mobile installation)** Maintenance
Ship impact	Design **Operation**
Helicopter operations	Design Operations

For each priority area, a coarse analysis is made of human factors, to identify the main routes by which human intervention can cause an accident. Taking oil and gas production as an example, we can derive for operational personnel a table of primary and secondary causes. Similar analyses can be done for maintenance, drilling, well-operations etc. See Figure 3 (at the end of the paper) for examples of human factors analysis applied to process plant operation.

Evidence can be collected during a site audit of these risk areas to produce a diagram similar to the following. This shows how diverse evidence of shortcomings can be synthesised to a draw the finding that the standards for pipework isolation are inadequate.

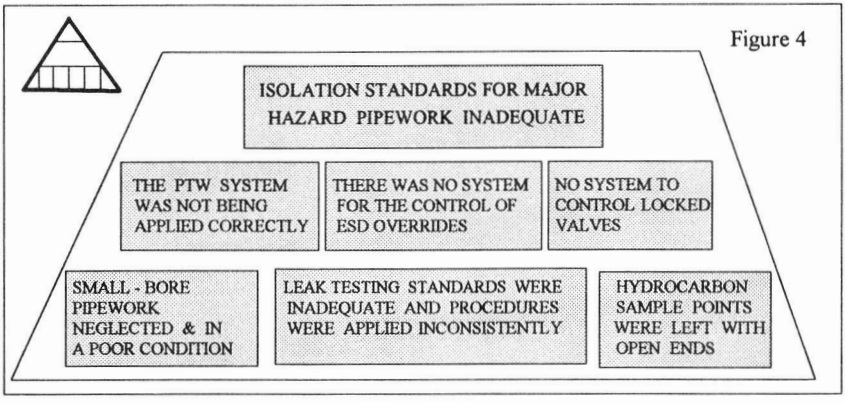

Figure 4

In the audit that produced this material a wide variety of shortcomings were also noted within the maintenance organisation and in the areas of monitoring and task-checking.

From this it can clearly be seen that risks of hydrocarbon release are not well controlled. If the auditors now present this information to senior management, we would expect these shortcomings to immediately be rectified. But as yet we have not addressed the root cause of the symptoms. Why are the symptoms present? What are the underlying causes in the management systems? Why are these shortcomings allowed to exist? To answer this question, we need more information about the organisation than can be provided by a site inspection. In order to trace shortcomings in the management of risk back to senior management, the auditor must apply the principles discussed earlier to achieve an understanding of the following:

The aims and objectives of the company, and in overview the organisational structure and its business activities

The senior management style and culture

The systems for identifying hazards and ranking risk

The systems for eliminating hazards and controlling risk

We are looking for coherence from the top to the bottom of the organisation. The measure of effectiveness is the clear and coherent linkage between the decision makers and the safety realities at the sharp end. So we start by dialogue with the senior management, exploring their corporate policies and their personal management style. Then we examine the detailed working of the organisation. We look for expansion and implementation of the high level policies and objectives and we form preliminary judgements on the likely efficacy of management systems and techniques. Eventually we conduct the detailed examination of management control of risks at the worksite. We sift and test our findings with successive levels of management. Finally once more at senior management level we can debate, having a coherent overview of the organisation, its effectiveness in managing health and safety risks.

A FRAMEWORK FOR THE AUDIT OF MANAGEMENT SYSTEMS

Achieving a coherent overview of the effectiveness of an organisation is a challenge of information generation, interpretation, judgement and synthesis. In order to assist in the process we have developed a framework model of management in complex organisations. Ref. Figure 5 (a) & 5(b).

The model fulfils several purposes, namely:

- to assist the auditor in differentiating between the roles of different levels of management in an multi-layered organisation;
- to provide an aid to checking if an audit system achieves adequate coverage, in terms of both breadth and depth, of the essential elements of the management system.
- to provide a simple mechanism for synthesising evidence from different parts and different levels of the organisation into findings related to the effectiveness of senior management.

The model is founded on two main principles:

- Management nodes - Organisations are run by people, not management systems. Therefore a useful audit tool needs to focus on the role of individuals at key nodes in the organisation.

- Management control systems - At its simplest, this involves setting objectives, having a system to achieve these objectives, setting performance standards and having the means by which adherence to these standards can be monitored. The model draws additionally on the HSE publication, HS(G) 65, "Successful Health and Safety Management".

The model distinguishes three main divisions of management function:

a.. Cascade of policies and objectives down the levels of an organisation.

b. Management's directive functions are broadly defined in two areas:

- What managers do (and plan to do) in control of key risks;
- How managers set the infrastructure for the organisation operating at the next level below.

c. Management's monitoring functions are defined in three areas:

- At first line management, where the local plan can be influenced;
- At middle management where local plans and organisational structure can be influenced;
- At senior management level where plans, organisation and policy can be influenced.

a) Cascade of Policy and Objectives

For simplicity, the model identifies four broad levels of management in an organisation:

- Top management - e.g. chief executive, main board.
- Senior management - e.g. asset manager, field manager, production manager.
- Middle management - e.g. OIM, maintenance superintentant, operations superintendent.
- First line management - e.g. process supervisor, maintenance foreman.

Top level management set the overall policy for the organisation. Corporate policies differ significantly in level of detail and specificity. At one end of the spectrum a policy statement can be little more than a mission statement or statement of intent. Before it can be implemented it must be developed into specific objectives or targets each with an associated means of measurement and criteria for success and each assigned to a specific individual. Thus a process of data-collection, evaluation and judgement takes place in order to transform a mission statement into a specific plan. The distinction from the point of view of the auditor between policy and the top level plan is academic. What matters is that the strategic aims of the top level management team are transformed into measurable objectives for implementation by senior management.

In order to implement their own specific areas of the top level plan, senior management must develop their own policies and plans which cascade to the next level down and so on. The content and style of the plans become more and more specific until, at the workforce level they appear as site instructions and work procedures. This cascade process delineates the core activities in the organisation.

b) Management's directive functions

The model distinguishes between two types of management's directive activities:

- those activities which managers undertake personally in order to achieve their core objectives, in the cascade of management policy setting and planning;
- those activities which a manager undertakes in order to support and facilitate the work of subordinates, i.e. establish management control systems, technical and competence standards, and an organisational culture.

The central hexagons on the model, (Ref. Figure 5(a) & (b)), represent the policy setting and planning systems operating at each management level. The wrapping around these core policies and objectives is the planning and review cycle which takes place at each management level, in conjunction with line management and subordinates. The outer circle represents the organisation

which is present to enable, facilitate and support the core activities. Within the circles, influencing all activities is the element of organisational culture.

At any given management level, the organisation takes on a unique form. During the cascade process, corporate directives change form and emphasis, and this is reflected in the type of organisational structures that form at different management levels. At all levels in a successful organisation, competence of staff must be assured, control systems must be effective, communication processes must meet the needs of individuals and people should work within a culture of co-operation with the corporate and local policies. These objectives are quite rightly achieved by different means at different levels in the hierarchy.

At the highest levels in the hierarchy, the senior management may well exercise considerable influence on the nature of the organisation in which they themselves function and also on the nature of the organisation in which their subordinates function. Lower down the hierarchy, middle and junior management will exercise local influences.

An auditor should try to identify the different influences at work in an organisation and distinguish the level of authority to which specific characteristics of the organisation can be attributed. This model provides a framework within which this analysis can take place.

c) Monitoring and Review

Management systems must be in place not only to control the effectiveness of the policies and plans which form the core activities of the organisation, but also to control the methodology by which the aims and objectives of the policy and plans are realised. Management must recognise that an effective organisation is one of the most critical factors in achieving their objectives, and that the organisation must itself be managed and controlled in order to be effective.

Monitoring systems must be tailored to the management levels which exercise the appropriate degree of control. i.e. monitoring of the effectiveness of local plans can realistically take place at local level, but the effectiveness of the local organisation must be reviewed at the management level which dictates the organisation. Similarly, review of the effectiveness of policy decisions must take place at the management level which sets policy.

The detail of which individuals, by what means and at what level in an organisation take part in the monitoring and review process is a matter for the auditor to assess.

Monitoring can be either active, in that the reviewing manager actively seeks evidence, or indirect, in that the management act on feedback from subordinates. Both are valuable management tools. The auditor should assess if the balance between the two approaches is adequate to effect control within the organisation.

AUDIT STANDARDS, EVIDENCE COLLECTION & SYNTHESIS

So far in this paper we have described how the principles of risk based auditing lead to an audit scope, how the scope can be related to the management framework and how this framework can be used to compile and analyse information about an organisation.

In this last section we put forward the view that the success of this type of audit depends on the synthesis of good quality evidence. The details of interview technique, on-site inspection and good audit practice have been covered in other texts, some of which are listed in the references on page14. Also both the American and UK Institutions of Chemical Engineering have produced guidance on good industry practice for process operations and maintenance activities. Specific guidance is available for some offshore operations. HSE draws on all such sources.

During auditing we expect standards to fit the context and the application specific to the individual company. In some cases standards will be set by regulation or codes of practice, but these will cover few situations. We endeavour, where standards do not fit our expectations, to debate with the auditee and test the strength of each expectation before forming a final judgement. The audit will have a greater chance of success if:

Expectations are objective, not subjective. Where subjective judgements are made, these are tested in debate with the auditee

Regarding evidence, it is a commonly held view that auditors require written evidence of activities completed successfully. Auditees often feel obliged to produce a prodigious collection of paperwork by which means they hope to convince the auditor of the effectiveness of the management system. The shortcomings of such an approach can be illustrated by a few examples.

During two audits of North Sea construction projects, full quality assurance and verification documentation was found for equipment not installed or installed up-side down. In the first audit the missing equipment was a fire detection system. In the second the valves incorrectly installed were the isolation valves on relief lines. These valves also inputted to an ESD system, for which full proof-testing documentation was again available, although the system could not function. These are just two examples of where documentation does not necessarily reflect reality. Audit interviews can give a different picture.

In another instance, the records showed that a shift team were fully trained to operate a gas turbine. However, the audit revealed that the shift team had been trained on the morning immediately following a night shift. They had been too tired to absorb what was an intensive session of theoretical and practical training and were quite unprepared to operate the equipment themselves.

In considering how evidence is used, it is through the synthesis process that the underlying causes of failures are determined: The underpinning principle here is one of :

Balance, consistency, coherency, focus

The synthesis process requires that the raw evidence be collected together and grouped into the categories identified in the framework model. Starting at the bottom of the pyramid ie at the worksite, low level evidence is collected regarding worksite conditions and local management systems. From low level evidence, higher level findings or deductions emerge. This must be tested against knowledge of the middle management systems and the individual managers. Thus as evidence of the management systems is mixed with deductions from lower levels, the findings accumulate and are ordered, and a picture builds of an organisation in the same way it might build of an individual. Strengths and weaknesses are identified and a pattern of logic links begins to emerge which connect effects at lower level to a causes at a higher. It is essential to question and test the validity of evidence and deductions with line management at each stage in the synthesis in order to guard against fitting evidence to a pre-determined plan. The cause and effect logic needs to be strong both up the hierarchy and in the relationship between departments.

Returning to the case study, we can now complete the picture which started with Figure 4 using further evidence collected during the audit.

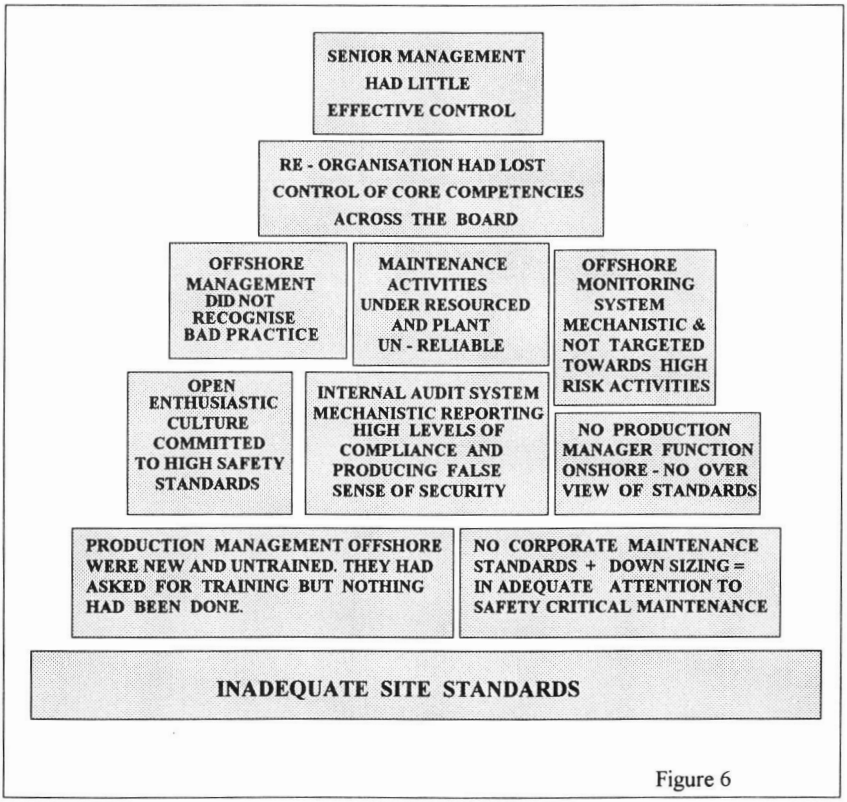

Figure 6

Presented to senior management, we now have a basis for discussion of the strengths and weaknesses of the company's control of risk. Some of the conclusions can be unwelcome and thereby subject to criticism. A strong, logical and evidence-based link from the risks at the worksite to the senior levels of management is essential. In response we expect senior management to make a fundamental review of their organisation, strategy and resources in order to address the concerns raised in the audit.

COMMON FINDINGS IN AUDITS ACROSS THE OFFSHORE INDUSTRY

Since this audit approach produces findings which are very much specific to an individual company, a direct comparison of findings is not straightforward. However, we have found that with increasing breadth of experience, trends and common themes can be identified across an industry.

In the offshore industry we notice a consistent and significant weakness in management audit / feed-back systems. We find that this is true at all management levels, from offshore monitoring schemes which are over-bureaucratic and mechanistic through to either mis-directed or non-existent management audit systems. In the case study, the company had used a proprietary audit system for some years and had developed confidence in it. They were naturally sceptical of our audit results, but found the arguments sufficiently compelling to conduct their own internal review. In response, they changed their whole approach to auditing to one consistent with the method described here.

Another company adopted a quality management audit system as it's corporate audit model. Although a sound concept, the implementation was such that only verification auditing took place, where the emphasis is on compliance with procedures and written evidence. This company had a highly bureaucratic management system which some managers openly described as incomprehensible. The company also suffered from a culture which penalised mistakes severely. As a result, the audit system as implemented served only to re-inforce the bureaucracy and blame-culture and did little to improve safety standards.

COMPARISON WITH OTHER AUDIT SYSTEMS

This audit approach was designed to take an overview of the effectiveness of senior management. It is complementary to existing techniques of inspection and verification. In the detail of interview technique and evidence gathering both at site and middle management level it is little different from most recognised audit systems, except for the fact that synthesis of evidence rapidly departs from the framework model and very quickly becomes free-format. Towards the end of the process a new framework of logical argument has developed which is unique to the particular company. Conventional audit techniques at their best show senior management the strengths and weaknesses of the middle management systems. At their worst, they mislead senior management and divert scarce resource away from the key risk areas. This approach aims to face senior management with the strengths and weaknesses of their own management and in the process to convince them to make changes in policy, resource levels, organisational structure, management style and culture which will help to redress the problems. Most importantly, we aim to leave senior management

with a recognition of the need for effective feedback loops, which will reveal in a constructive way the ongoing problems in the development of a safe organisation.

References

1. Centre for process safety of the Americal Institution of Chemical Engineers. 1992 - Plant guidelines for technical management of chemical process safety.
2. Centre for process safety of the Americal Institution of Chemical Engineers - 1993 -Guidelines for auditing process safety management systems.
3. Townsend, A. Maintenance of Process plant. IChemE.
4. Petersen, D. Techniques of safety management - a systems approach.
5. Cullen Report.
6. HS(G) 65. 1993. Successful Health and Safety Management. HSE Books.
7. Bea, RG; Moore. W.H. Management of human & organisational error in Operational Reliability of Marine Structures.

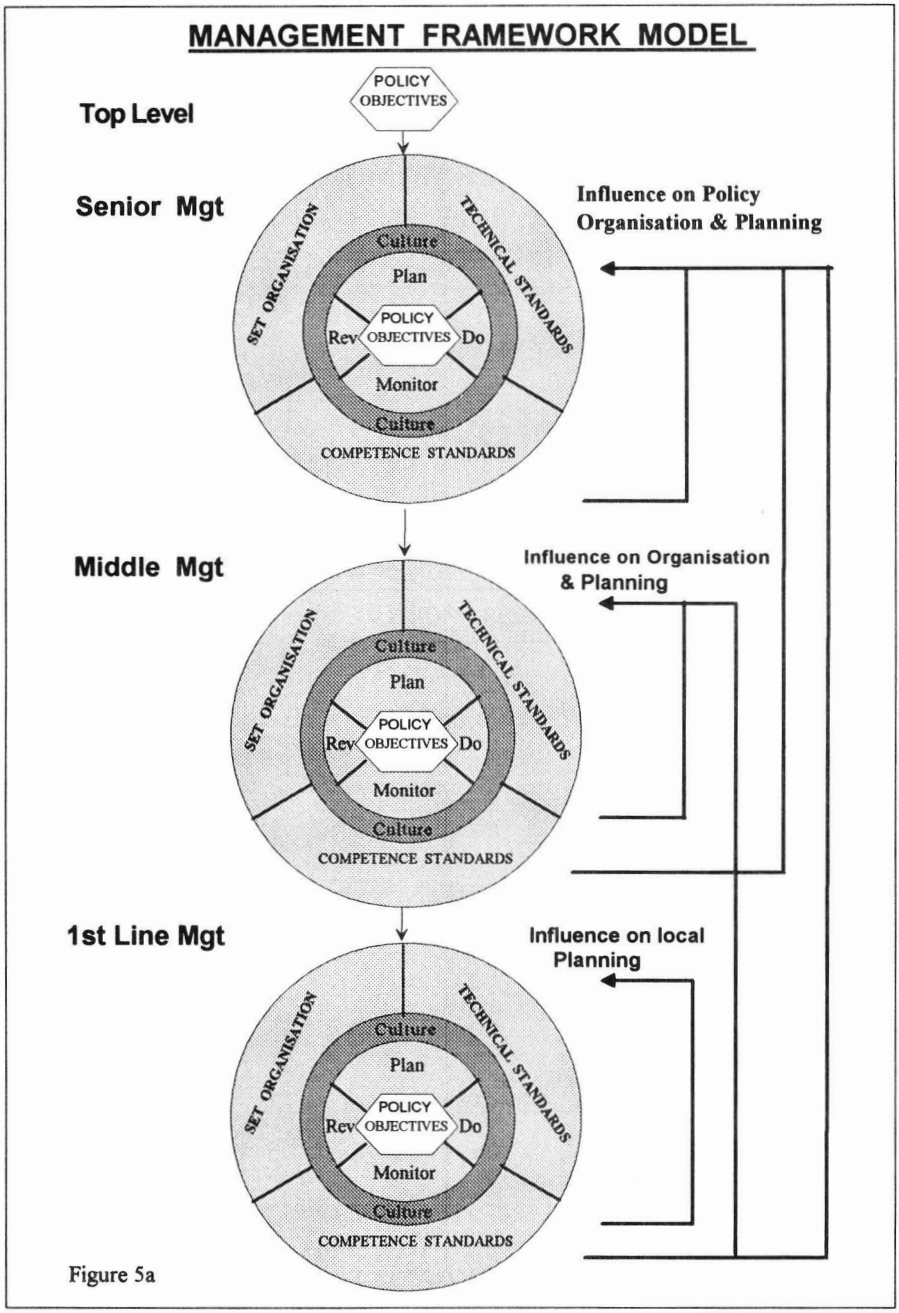
MANAGEMENT FRAMEWORK MODEL
Top Level
POLICY OBJECTIVES
Senior Mgt
SET ORGANISATION
TECHNICAL STANDARDS
Culture
Plan
Rev
POLICY OBJECTIVES
Do
Monitor
Culture
COMPETENCE STANDARDS
Influence on Policy Organisation & Planning
Middle Mgt
Influence on Organisation & Planning
1st Line Mgt
Influence on local Planning

Figure 5a

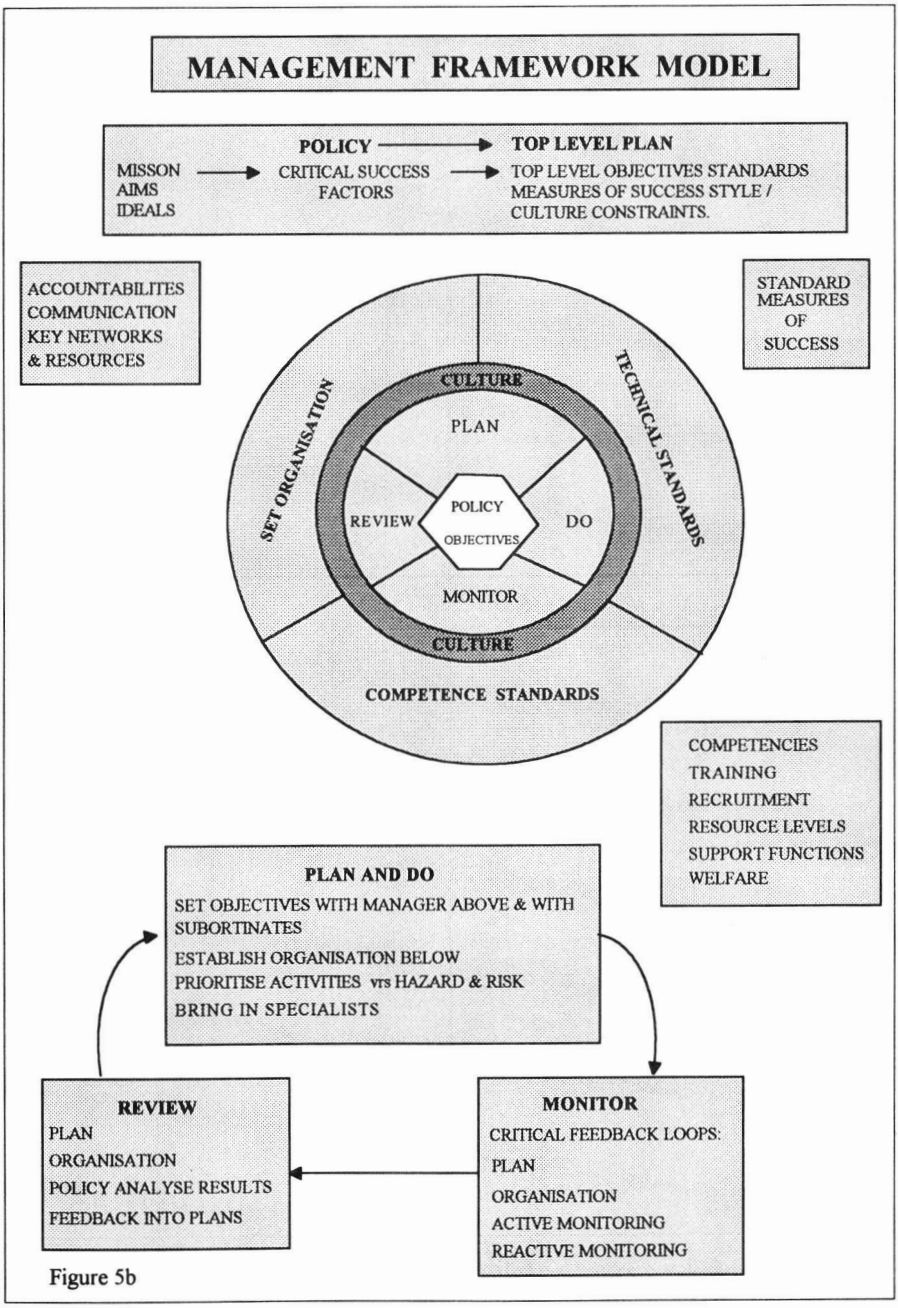
MANAGEMENT FRAMEWORK MODEL
MISSON
AIMS
IDEALS
POLICY
CRITICAL SUCCESS FACTORS
TOP LEVEL PLAN
TOP LEVEL OBJECTIVES STANDARDS MEASURES OF SUCCESS STYLE / CULTURE CONSTRAINTS.
ACCOUNTABILITES
COMMUNICATION
KEY NETWORKS
& RESOURCES
STANDARD MEASURES OF SUCCESS
SET ORGANISATION
CULTURE
PLAN
REVIEW
POLICY
OBJECTIVES
DO
MONITOR
CULTURE
TECHNICAL STANDARDS
COMPETENCE STANDARDS
COMPETENCIES
TRAINING
RECRUITMENT
RESOURCE LEVELS
SUPPORT FUNCTIONS
WELFARE
PLAN AND DO
SET OBJECTIVES WITH MANAGER ABOVE & WITH SUBORTINATES
ESTABLISH ORGANISATION BELOW
PRIORITISE ACTIVITIES vrs HAZARD & RISK
BRING IN SPECIALISTS
REVIEW
PLAN
ORGANISATION
POLICY ANALYSE RESULTS
FEEDBACK INTO PLANS
MONITOR
CRITICAL FEEDBACK LOOPS:
PLAN
ORGANISATION
ACTIVE MONITORING
REACTIVE MONITORING

Figure 5b

Figure 3 - Examples of the Impact of Process Human Factors on Offshore Process Facilities

Major Hazard	Primary leading Event	Secondary Leading Event
Significant gas leak followed by ignition and fire/explosion.	Gas leak from open or loose end.	Failure in process isolation. Failure in process recommissioning of equipment Failure of sampling system. Failure to control interlock system - e.g. pigging operations.
"	Blowout of a gas joint.	Corrosion failure due to maloperation. Inadequate leak-testing of joint. Loss of control of locked valves.
"	Overpressure of vessel.	Override or isolation of alarm or trip systems. Incorrect identification of isolation or relief systems. Failure of process emergency response. Surge condition exceeds capacity of relief - due to process mal-operation. Fire in vicinity of vessel. Incorrect start-up procedure followed. Inadequate testing of shutdown system. Failure to detect blockage of vents/reliefs. Failure to control levels in catch-pots.
"	Overpressure of pipeline.	Failure in process recommissioning Fire in vicinity of pipeline. Incorrect identification or isolation of relief system. Loss of control of locked valves. Corrosion, erosion failure due to mal-operation - e.g. loss of passivation layer.

Fig 3 contd.

Major Hazard	Primary leading Event	Secondary Leading Event
"	Mechanical damage to pipework fitting	Unused fitting not removed. Inadequate protection of spigot point. Excessive vibration due to equipment mal-operation. Impact of high-pressure jet - e.g. pinholed water main.
Significant gas leak followed by ignition and fire/explosion.	Internal fire/explosion in vessel or pipeline	Incorrect re-commissioning procedure. Incorrect start-up procedure Inadequate testing of shutdown system.
"	Impact from crane or lifting device	Inadequate control of process / maintenance interface.
"	Cross-contamination of drains.	Loss of control of drain valves.
"	Cross-contamination of vents.	Loss of control of isolations / locked valves.
"	Failure to control ignition sources.	Failure to control portable electrical equipment. Failure to control burning and welding. Failure to control portable ignition sources e.g. matches, cameras etc. Incorrect philosophy on use of deluge system