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Assessing the safety of staffing arrangements for process operations in the chemical and allied industries

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Assessing the safety of staffing arrangements for process operations in the chemical and allied industries

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This study has been completed on behalf of the Hazardous Installations Directorate (HID) of the Health and Safety Executive who have observed that a number of chemical sites are taking steps to reduce staffing levels in their operating teams. There is a concern that such reductions could impact the ability of a site to control abnormal and emergency conditions and may also have a negative effect on staff performance through an impact on workload, fatigue, etc.

A method has been developed that flags when too few staff are being used to control a process. It is not designed to calculate a minimum or optimum number of staff. However, if a site finds its staffing arrangements 'fail' the assessment, it is not necessarily the case that staff numbers must be increased as other options may be available. The method also allows duty holders to benchmark how they manage staffing arrangements.

The method has been trialed and from the experience and comments of those participating, it is judged the method brings staffing issues into the open, is practical, useable and intelligible to duty holders and inspectors, and is robust and resistant to manipulation and massaging of its output.

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EXECUTIVE SUMMARY

Introduction

This study has been completed on behalf of the Hazardous Installations Directorate (HID) of the Health and Safety Executive who have observed that a number of chemical sites are taking steps to reduce staffing levels in their operating teams. There is a concern that such reductions could impact the ability of a site to control abnormal and emergency conditions and may also have a negative effect on staff performance through an impact on workload, fatigue, etc.

HID identified the need for a practical method that organisations could use to assess their required staffing levels and the impact on safety of any reduction in operations staff. The method is to help companies in the chemical and allied industries justify appropriate levels of operations staff by a suitable and sufficient assessment, and enable HID inspectors to apply consistent standards on staffing levels.

Method

The method concentrates on the staffing requirements for responding to hazardous incidents. Specifically, it is concerned with how staffing arrangements affect the reliability and timeliness of <u>detecting</u> incidents, <u>diagnosing</u> them, and <u>recovering</u> to a safe state.

The method is designed to flag when too few staff are being used to control a process. It is not designed to calculate a minimum or optimum number of staff. If a site finds that its staffing arrangements 'fail' the assessment, it is not necessarily the case that that staff numbers must be increased. Other options may be available.

The method is in two parts. The first is a *physical assessment*, the second is a *ladder assessment*.

Physical assessment

The physical assessment tests the staffing arrangements against six 'principles':

i) There should be continuous supervision of the process by skilled operators, i.e. operators should be able to gather information and intervene when required;

ii) Distractions such as answering phones, talking to people in the control room, administration tasks and nuisance alarms should be minimised to reduce the possibility of missing alarms;

iii) Additional information required for diagnosis and recovery should be accessible, correct and intelligible;

iv) Communication links between the control room and field should be reliable. For example, back-up communication hardware that is non-vulnerable to common cause failure, should be provided where necessary. Preventive maintenance routines and regular operation of back-up equipment are examples of arrangements to assure reliability;

v) Staff required to assist in diagnosis and recovery should be available with sufficient time to attend when required;

vi) Operating staff should be allowed to concentrate on recovering the plant to a safe state. Therefore distractions should be avoided and necessary but time consuming tasks, such as summoning emergency services or communicating with site security, should be allocated to others.

The assessment is in the form of specific questions, each requiring a yes/no answer. The questions are arranged in eight trees (an example is shown in Figure I). The choice of scenarios for assessment is critical and must consider the worst cases both in terms of consequence and of operator workload.

Ladder assessment

Organisational factors are assessed using ladders (see the example in Table I - note: the dotted line represents the boundary between acceptable and unacceptable). There are twelve ladders in total.

Figure I Example Tree from the Physical Assessment

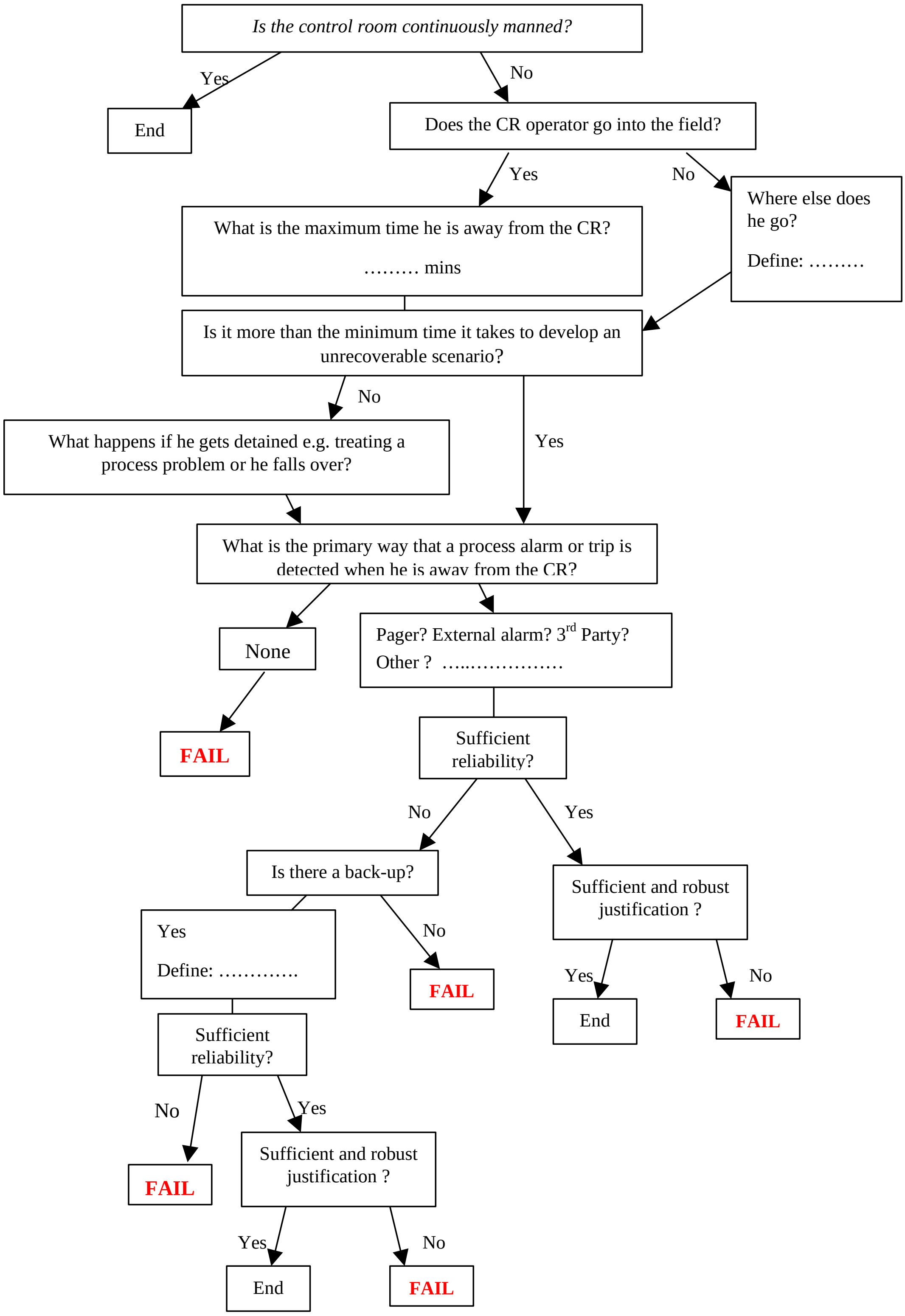


Table I Example ladder (for training & development)

Grade	Description	Explanation of progression	Rationale supporting assessment
A	**Process/procedure/staffing changes** are **assessed** for **the required changes** to operator **training and development** programmes. **Training** and **assessment** is provided and the **success** of the **change** is **reviewed** after implementation.	The training and development system is dynamic and integrated into the management of change process.	
B	**All operators receive simulator or desktop exercise training** and **assessment** on **major hazard scenarios** on a **regular basis** as part of a **structured** training and development **programme**.	Operators get a regular opportunity to practice major hazard scenarios through physical walk through's or simulators or by desk-top talk throughs.	
C	There is **a minimum requirement** for a **'covering' operator** based on **time per month** spent as a **CR operator** to ensure **sufficient familiarity**. Their **training and development** programmes **incorporate** this requirement.	It has been recognised that anyone covering the control room must be competent and their skills kept up to date.	
D	**Each operator** has **a training and development plan** to progress through **structured, assessed skill steps** combining **work experience** and **paper based** learning and training sessions. **Training needs** are **identified** and **reviewed regularly** and **actions** taken to **fulfil needs**.	The training and development needs are identified, provided and reviewed on an individual basis allowing operators to improve and extend their skills and understanding. It provides operators with a motivation to improve and continue to develop.	
W	**All operators** receive refresher training and assessment on **major hazard scenario** procedures on a **regular, formal** basis.	The need for formalised regular refresher training for major hazard scenarios has been recognised as essential when they are such infrequent events with severe consequences.	
X	**New operators** receive **full, formal induction training** followed by **assessment** on the process during **normal operation** and **major hazard** scenarios	Full training and assessment for new operators, it is formalised and covers normal operation plus major hazard scenarios.	
Y	There is an **initial** run through of **major hazard** scenario procedures by **peers**.	Only an informal briefing on major hazard procedures is provided to new operators.	
Z	There is **no evidence** of a **structured** training and development programme for operators. Initial training is **informally** by peers.	Poor practice, staffing arrangements do not fulfil any of the rungs above.	

Implementing the method

Good practice will be to apply the method in full and to review and reapply the method periodically.

It is recommended the staffing assessment be managed in a similar vein to other process safety assessments, such as HAZOP studies or risk assessments supporting a safety case.

It is recommended that the assessment be co-ordinated and facilitated by one person who is technically capable, has appropriate Human Factors skills and has experience of applying hazard identification and risk assessment methods. The role is similar to that of HAZOP chairperson.

In addition, it is suggested the assessment team constitute:

- control room operators - experienced and inexperienced operators, and operators from different shift teams;
- staff who would assist during incidents, perhaps in giving technical advice to operators or with tasks such as answering phones;
- management or administration staff with knowledge of operating procedures, control system configuration, process behaviour, equipment and system reliability, and safety (including risk assessments and criteria).

Teams may require assistance from Human Factors specialists.

Analysing changes to staffing arrangements

Changes in staffing arrangements should be evaluated prior to implementation. Any change that could alter the rating from the method is considered to be a change in staffing arrangements. A guiding principal is that changes should not lead to a reduction in the rating from the staffing assessment method.

A straightforward procedure for analysing changes is recommended:

- Produce an up-to-date baseline assessment of the existing arrangements;
- Define the proposed change, and evaluate it using the assessment method, modifying the plans until an equal or better rating is achieved;
- Re-assess the arrangements at a suitable time after implementation (within six months).

Conclusions

The method has been trialed and from the experience and comments of those participating, it is judged the method:

- that brings staffing issues into the open,
- enables the adequacy of staffing arrangements to be gauged and the impact of staffing changes, particularly reductions, to be assessed;
- is practical, useable and intelligible to duty holders and inspectors; and
- is robust and resistant to manipulation and massaging of its output.

It is anticipated that the method will bring benefits in terms of:

- reinforcing the regulatory framework;

- providing greater transparency and thereby facilitate dialogue between duty holders and inspectors;
- enabling benchmarking across organisations; and
- stimulating enhancements in duty holders safety management systems.

Future development of the method

The method described in this report is ready to be applied. Additional refinement through repeated practical application is anticipated and the ladders in particular could be further enhanced as greater application experience is gained.

The method's structure allows it to be added to (new ladders or assessment trees) or modified (e.g. revision of the ladders). It is anticipated that expansion or amendment will come as experience of applying the method is accumulated and 'best practice' evolves. The method may benefit in being used in conjunction with task analysis or other specialised assessment tools.

Although the method has been developed primarily to assess staffing arrangements in control rooms, case study experience has demonstrated that often it is necessary to assess the entire shift operations team and the method easily lends itself to being applied in this way.

CONTENTS

1. INTRODUCTION

1.1 OVERVIEW

This study has been completed on behalf of the Hazardous Installations Directorate (HID) of the Health and Safety Executive who have observed that a number of chemical sites are taking steps to reduce staffing levels in their operating teams. There is a concern that such reductions could impact the ability of a site to control abnormal and emergency conditions and may also have a negative effect on staff performance through an impact on workload, fatigue, etc.

HID identified the need for a practical method that organisations could use to assess their required staffing levels and the impact on safety of any reduction in operations staff. The method is to help companies in the chemical and allied industries justify appropriate levels of operations staff by a suitable and sufficient assessment, and enable HID inspectors to apply consistent standards on staffing levels.

This report gives further background to the problem, describes the method that has been developed and summarises the results from trialing the method in the form of case studies.

1.2 ABOUT THE PROBLEM

The context of staffing issues in the chemical and allied industries

Staffing arrangements in the chemical and allied industries have been changing. Skilled and experienced manpower is now an expensive component of industrial activities and strenuous efforts have been made to effect economies by reducing manpower requirements by various measures.

As well as increasing the scale of unit operations to reduce the manpower required to give a defined annual output, organisational thinking has changed and initiatives to delayer, multiskill and enhance team working have also had the effect of reducing staffing. That is not to say these organisational changes have ignored safety, indeed they are thought to bring safety benefits in some contexts. However, the concern remains that circumstances may arise in which too great a strain is placed on staff and safety margins are compromised as a result. For example, is it the case that the effect of staffing changes on the ability of operatives to deal with truly abnormal situations is not adequately considered, or that subtle and chronic effects on human performance are not allowed for?

These changes have not only led to questions over staffing numbers. Other issues such as lone working have emerged. Confounding the organisational changes are the technology changes that have occurred, particularly in the area of control systems, where the switch from pneumatics to electronic, software driven, systems has radically changed the roles of operators.

Is there evidence of safety being compromised?

When studying previous incidents at refineries, terminals and similar installations it is extremely difficult to determine from accident reports or databases which accidents were affected by staffing levels. Most investigators tend to lay the blame on hardware failure, procedural failings or operator error. It is rare for a report to state that an accident resulted from deficiencies in manpower numbers. However training is often mentioned and heavy workloads on operators during process upsets is referred to frequently, especially in connection with “alarm floods”.

Why should it be the case that staffing is seldom identified as a contributory cause in accident case studies? Is it that staffing level has only recently become a significant contributor, in which case incidents where it has been a factor are not yet widely documented? Alternatively, could it be that staffing hasn't been commented on because it is less apparent than (say) poor operability or weaknesses in design safety reviews, or analysts are less confident in picking out staffing as a cause?

Knowingly or not, accident analysts may have been treating staffing as a 'given' and are therefore implying the causes they've nominated such as operability issues, alarm design or whatever, have not compensated adequately for the staffing (and other) constraint(s). Certainly investigators have picked out direct causes that one can imagine to have been sensitive to staffing arrangements - oversight of alarms, delayed response actions, bottlenecks in communications – but have not named staffing as a contributor.

It is probable that the lack of evidence for staffing levels being an accident contributor is due to all of the above:

- moves to the present levels of staffing are relatively recent;
- it is not straightforward to tie down staffing as a cause of accidents; and
- staffing arrangements may well have been treated by analysts as a 'given', whether deliberately or not.

Whatever the state of documented evidence from the chemical sector, it seems logical to hold the view that any particular plant will have a safe minimum staffing level. If staffing is cut, it seems only natural to expect that the remaining staff will have to adapt to the new circumstances and, perhaps, operate the plant differently. There may be certain operational manoeuvres that are beyond them due to the shortage of hands. For example a team may not be able to respond to a trip as they used to, and have to accept that they must shut-down the plant rather than attempt to recover as they once did. Anecdotal evidence suggests this is happening. A search through the literature revealed a demonstration that a smaller team cannot handle a process safely. Research using nuclear power plant simulators has demonstrated that there comes a point when a reduced team cannot keep control.

The obligations of stake holders

Demonstration by duty holders of the safety of their operations is of course part of the regulatory framework. Therefore, duty holders should be able to justify their staffing arrangements and integrate the topic into their safety management system. Hence a staffing assessment should not be a once-off exercise, but should be reviewed and revised. Furthermore, it would be incorporated into:

- the organisation's control of change processes; and
- its learning processes.

In respect of change management the control of organisational change has lagged the control of hardware change. Ideally, an organisation would understand how a staffing change would alter its performance and compensate accordingly. It would foresee how a change would manifest itself – e.g. slower response times, more upsets resulting in outages - and could adjust other organisational, control system or process parameters as necessary.

An organisation would also appreciate that it may need to take one step at a time, and gather operational experience before concluding that a counterbalancing action, such as upgraded alarm handling software, can be considered to be satisfactory and only then change its staffing arrangements.

In respect of an organisation's learning processes, the observation made above about staffing arrangements not being picked out, for whatever reason, as a contributor to safety performance will have had a bearing on the ability of organisations to learn from experience – their own as well as that of others.

Are there methods to help duty holders meet their obligations?

There appears to be a shortage of sound and robust methods that are practical for organisations to use in helping them fulfil their requirement of demonstrating adequate safety in respect of control room staffing:

- Human factors design methods tackle job and task issues by concentrating on layout, interface design and working environment;
- Workload methods, using time line analysis, are relevant and suited to assessing highly proceduralised tasks. Some activities, such as start-up / shut-down, certain upset and emergency conditions could be analysed by this form of technique;
- Techniques such as functional analysis and scenario analysis can be used in control room appraisals, though their focus is not staffing matters;
- As has been mentioned, there is a concern that accident investigation methods are weak in picking up staffing issues;
- Management audits (in the public domain) address some relevant factors but are not sufficiently focused, being too coarse to give valid conclusions.

A fuller review and appraisal of techniques is given section 3, from which it is concluded that many of the techniques are research tools, requiring specialist skills to interpret even though they may be straightforward to apply. A method tailored to assessing staffing arrangements, and designed for general use, has not been produced.

So what is needed?

In summary, an assessment method is needed which helps duty holders to understand the issue of staffing arrangements in the context of their organisation and their operations. At a practical level, the method would shed light on the consequences of altering their staffing arrangements, pointing out how a change could manifest itself in the control of their plant, and assist them in understanding the implications of trade-offs between staffing arrangements and other organisational or technological factors.

At a higher level, the method would enhance their safety management system, prompting them to control changes and to learn about their staffing arrangements from their experience.

1.3 AIMS AND BENEFITS OF THE STUDY

The aims of this study are to develop a method for assessing staffing arrangements that:

- brings staffing issues into the open,
- enables the adequacy of staffing arrangements to be gauged and the impact of staffing changes, particularly reductions, to be assessed;

- is practical, useable and intelligible to duty holders and inspectors; and
- is robust and resistant to manipulation and massaging of its output.

The benefits of a structured assessment will be the:

- reinforcement of the regulatory framework;
- provision of greater transparency and thereby facilitate dialogue between duty holders and inspectors;
- enabling of benchmarking across organisations; and
- stimulation of enhancements in duty holders safety management systems.

1.4 APPROACH TO THE STUDY

1.4.1 Philosophy of the method

Staffing is to be treated as one of the contingent factors within the context of how organisations are designed for the demands of their operations. Hence, it is intended to take account of sociotechnical factors (process hardware, control technology, human and organisational factors) and acknowledge there is no single 'ideal' organisational arrangement that must be adopted by all organisations. Therefore, the method should give consideration to how organisations handle the trade-offs between staffing numbers and, for example, interface technologies, automation, communication arrangements, task allocations, team structure etc.

It is also intended the method indicates how 'comfortable' an organisation is in respect of its staffing arrangements: i.e. given its other organisational parameters and the operations it is engaged in, how close to 'unacceptable' is its staffing arrangements?

1.4.2 Development of the staffing assessment method

A five stage development plan is followed:

- Identification of factors and assessment techniques - the first stage is to review literature and other evidence to identify what factors the assessment method should evaluate, and what analysis techniques are most apt;
- Specification of the method - the second stage is to set out the requirements for assessment method;
- Method development;
- Testing and refinement of the method - two forms of testing are used, piloting with HSE Inspectors and trialing at sites; and,
- Writing guidance - lastly, guidance on applying the method periodically and when planning a change to staffing arrangements.

2. IDENTIFICATION OF FACTORS

2.1 INTRODUCTION

This section summarises a search for staffing factors considered to contribute to the safety of process control tasks and, hence, should be examined by the assessment method.

2.1.1 Approach

Through a search, a sample of relevant literature is summarised below. The search is restricted to literature focusing on process control operations, particularly on control room staffing and control room operators. It is not an exhaustive review. Compiling such a review would be a lengthy task. The priority is to identify factors that a staffing assessment method should address and gain an appreciation of how these factors can vary.

2.2 LITERATURE REVIEW

Factors from research on staffing levels

A research programme into the effect of control room design and control room staffing on operator and plant performance has been carried out in the Loviisa nuclear power station, Finland and Halden Man Machine Laboratory (HAMMLAB) in Halden, Norway (Hallbert et al 1997, 1995, Sebok 2000). Combinations of crew size and control room design (advanced versus conventional) were tested over five scenarios (steam generator tube rupture, sustained total loss of feedwater, loss of offsite power, interfacing system loss of coolant accident, and steam generator overfill). The scenarios required different problem-solving techniques to mitigate disturbances.

The study used measures of situation awareness, operator workload, team performance and crew performance, where:

- Team performance covered: communication, openness, co-ordination as a crew, team spirit, task focus and decision making; and,
- Crew performance covered: selection of proper mitigation path, control of the plant, crew communications, confidence in their own performance and decision making

Dependency between these measures and the manipulated variables was shown to be significant. Sebok concludes that if the interface presents data rather than information (i.e. the conventional type of plant interface) thereby requiring operators to integrate information, a larger crew appears more effective. Essentially, the extra person is available to help gather information and perform tasks. In an advanced, highly computerised interface, where information is integrated, an extra person appears to be of little benefit. She also notes the findings do not support vendor assumptions that computerised interfaces and plant design features automatically reduce the operating crew's workload. Rather, the opposite is true, and the increase is even more pronounced in smaller crews. She advises that consideration should be given to workload before staffing levels are reduced in advanced plant control rooms.

Although not examining staffing levels, the results of Endsley and Kaber (1999) also confirm that the level of technology in the control systems (termed 'levels of automation') impacts performance. They judge that when the operator generates the options and the computer implements them, the results during normal operations are superior compared to purely manual control or higher levels of automation involving computer generation of options. They judge that operators benefited most from physical implementation assistance and were actually hindered when assistance was provided with higher level cognitive functions.

Factors from research on process control operators

Kecklund and Svenson (1997) asked control room operators to report on the strategies they use to maintain their performance. Operators stated they use the organisation as a resource when coping with more demanding work situations such as arise during outages, by handing over tasks to others, postponing activities to the next shift, etc. They also judge that organisational factors, such as planning and shift change had a bearing on misinterpretation errors. They also indicated lack of education, experience and knowledge as important contributors to misinterpretation errors, underlining the value of training.

Vicente, Mumaw and Roth (1998) also investigated strategies used by operators. They found that, in regard to normal operations, operators learn to manipulate their information sources and regulate their workload to reduce the potential for monitoring errors. They note the techniques used by operators to regulate their workload and make monitoring more manageable such as approving and scheduling work requests in such a way that monitoring is not ignored or degraded. They feel that, to achieve this goal, operators must have a well calibrated sense of their capabilities that they can use to set priorities so as not to overextend themselves. They state that there are a number of generic methods which operators use to regulate their workload when prioritising jobs to make sure it does not reach their limits. Among the factors they feel operators give consideration to are:

- What else is going on at the same time?
- Which meters will be unreliable or unavailable?
- What is the worst case scenario with respect to the potential impact on operation?
- How much attention and dedicated effort will the job require?
- How much field support is it going to need?
- Does the job have to be done now (i.e. is it urgent)?
- Is there a time later in the day when the demands will be lower?

While noting that operators obtain information from many sources - control room displays, alarms, other control room operators, written reports or readings taken in the field, communication with field operators - Vicente et al discuss the impact of new technology on how operators gather information. They consider that with old, hardwired control systems, operators had to expand the degrees of freedom in the control room design, which they did by adding post-it notes, creating external reminders and such like. In contrast, with new technology operators have great flexibility in how information is presented. They have to cut-down the degrees of freedom. They imply operators are not finding this straightforward as they observe operators resorting to post-its, tags and written messages just like the operators using old, hardwired technology.

Situation awareness is a variable mentioned by many researchers. Endsley's definition of situation awareness as 'the perception of the elements in the environment within the volume of time and space, the comprehension of their meaning, and the projection of their status in the near future' is referred to by others (e.g. Artman 1999, Hogg et al 1995). Hogg also notes that others have added that a critical characteristic of situation awareness is that it is a temporal state that is dynamically updated as the situation develops and new information is acquired. For example, an operator may predict an alarm based on awareness of the current situation and confirm or unconfirm this prediction as the situation, and hence awareness, develops.

Jensen (1999) examined how the alertness of operators can be supported. Focusing on the early morning hours, between 0300 and 0640, the activities assessed and their ratings by operators are shown below.

Table 2.1 Activities rated by operators for maintaining alertness (Jensen, 1999)

Activity	Rank	Average rating (max 100)		Rank	Average rating (max 100)
Splashing cool water on face	1	54	Consuming snacks with strong smell like peppermint	9	36
Drinking a cup of coffee	2	5	Making a tag for lockout / tagout procedure	10	35
Stretching while at work station	3	47	Chewing gum	11	34
Taking short walk within the control room	4	46	Discussing technical matters about plant operations	12	32
Discussing the weather	5	40	Drinking soda with no caffeine	13	28
Eating mid-shift	6	40	Recording activities in a log book	14	26
Cleaning up the work station	7	38	Passively monitoring a stable system	15	22
Consuming snacks with strong tastes	8	37	Reviewing materials for Licensing exam	16	10

Jensen recommends management provide support by:

- Assigning work that involves some muscular activity;
- Assigning work that stimulates the mind;
- Providing opportunities for control room personnel to get some exercise other than work-related;
- Grouping individuals into crews based in part on their sharing of interests; and
- Encouraging operators to make changes in routine during periods of passive monitoring.

In describing the first stage of a fatigue risk assessment method (for safety critical staff) Lucas et al (1996) judged that there are six aspects of working time pattern which influence fatigue:

- Length of period of duty;

- Intervals between duties;
- Recovery time;
- Rest breaks;
- Variability of shifts; and,
- Time of day.

Shift work is a sizeable topic in itself. Many factors have been explored: length of shift, shift cycle, choice in selecting shift pattern, relationship between physical demands and shift patterns, etc. See for example Rosa (1993).

A study by Attwood and Nicolich (1994) on the effects of shift schedules on performance of control room operators reveals that distractions can have a significant bearing on performance. Having set out to use a battery of three computer based tasks to compare different shift schedules, they found that operators reported being frequently interrupted while performing the tests to respond to alarms or the telephone. Also, during the daytime, distractions were many in a busy control room. They concluded from their results that operator performance was influenced more by the characteristics of the working environment in the control room than by the effects of shift work or time on task.

Desaulniers (1997) comments on approaches to stress management for control room operators. He considers stressful situations occur when a substantial imbalance exists between the demands imposed on an individual and the individual's ability to handle those situations. Abnormal and emergency conditions in nuclear power plant operations can be stressful due to the sudden increase in workload, real or perceived time constraints, and the potential for novel situations. The effects of stress are considered to be fourfold:

- *Narrowing and shift in focus of attention* - one of the most widely reported effects of stress on performance of cognitive tasks is that the performer's attention becomes more narrowly focused on cues central to a task and less sensitive to peripheral cues. As a result, the changes in performance that may be observed are impaired performance on peripheral tasks and enhanced performance on central tasks. Similarly, performance on tasks that require integration of many cues, or decision making that requires consideration of many options may be impaired because of the individual's decreased ability to allocate attention to the peripheral cues or options. Therefore, narrowing and shift in focus of attention could impair operator performance when:

  - Multiple tasks need to be performed or monitored simultaneously; or,
  - Multiple sources of information need to be monitored or consulted, some of which are less salient than others.

- *Reduced working memory* - when performance relies on working memory, stress will impair performance. Deductive reasoning, spatial manipulations, and arithmetic computations are all cognitive tasks that rely on working memory. Therefore, a reduced working memory capacity could impair operator performance when:

  - There is a heavy burden on mental simulation of plant systems or control actions;
  - There is significant requirement for mental computation;
  - Information from several sources must be integrated mentally; or

– Multiple small tasks are being managed simultaneously; or,

- *Time pressure effects* - stress can cause decision makers to perform as if they were under time pressure. Decisions under stress may be made more quickly, at the expense of accuracy, and decision makers may omit elements of the decision-making task. Therefore, stress-induced time pressure effects could impair operator performance when:

  – A series of simple decisions or judgements can be executed in succession or when speed of execution is not limited by the control room interface; or,

  – Complete and systematic analysis of information is required for effective decision-making.

- *Impaired crew communication patterns* - stress can result in a failure of work teams to pool information, thereby jeopardising effective situation assessment. It is a contributor to the 'groupthink' phenomenon in which there is a marked decrease in the exchange of discrepant or unsettling information for the benefit of maintaining group harmony (i.e. colleagues don't challenge each others' decisions). Impaired crew patterns can have a negative affect on operator performance when:

  – Control actions must be co-ordinated;

  – Indications of plant state are subtle or ambiguous; or,

  – Information important to effective decision making must be passed from crew members to the primary decision maker.

Desaulniers considers the following to be part of stress management:

- *Simulator training* - simulator training is, perhaps, the most effective tool available to address stress in the context of nuclear plant operations. Repeated training in plant emergency simulations is an important means of mitigating the effects of stress on plant operators by causing effective accident mitigation behaviours to become well-learned, routine behaviours that tend to be less susceptible to, if not facilitated by, stress. In addition simulator training eliminates or reduces novelty which is a potential source of stress. The ability to predict outcomes, even if the events are adverse and outside the control of the individual, can be less stressful than uncertainty.

- *Communications and team skills training* - training can reinforce the importance of pooling of information for effective decision-making and address barriers to effective communication, for example, the failure to challenge decisions of another crew member.

- *Procedure design* - principals of good procedure design minimise demands on working memory and distribute workload across crew members. Example good design principals are: including cautions prior to the step(s) to which they apply; the need for mathematical computations or conversions of units is minimised; the presentation is easy to refer to avoid reliance on recall.

Factors from control room technology research

O'Hara, Stubler and Kramer (1997) rated the significance on safety of technology features (and the management of technology) on personnel performance and plant safety. The effect of each feature on five factors was considered:

- Personnel role: change in functions and responsibilities;

- Primary tasks: change in the way tasks such as process monitoring, situation assessment, response planning, and response execution are performed;
- Secondary tasks: change in the way tasks such as navigating through displays, searching for data, choosing between multiple ways of accomplishing the same task, and deciding how to configure the interface are performed;
- Cognitive factors: change in situation awareness and workload; and,
- Personnel factors: change in the required qualifications or training of plant personnel.

They did not assess *Alarm system design* and *Staffing and crew co-ordination* as other research was ongoing (it is assumed these would have been rated as having high potential). Otherwise, the factors they rated as having high potential to change control room safety were:

- Design analyses and evaluation;
- Upgrade implementation;
- Computer-based procedures;
- Information design and organisation;
- Soft controls; and,
- Changes in automation.

The following were rated as having medium potential:

- Configuration control of digital systems; and,
- Maintenance of digital systems.

The following were rated as having low potential:

- Computerised operator support systems; and,
- Display device characteristics.

Alarm handling is a also a technical topic that has received attention (see HSE 2000).

2.2.1 Factors from other sources

Although reference to 'willingness' of operators to act has not been found in the literature reviewed, anecdotal evidence points to it being a factor of importance. Anecdotes take the form of operators being:

- reluctant to implement an emergency shutdown procedure because of the consequential product loss and potential damage to the plant; and,
- unwilling to divert product to a flare, even though an incident is imminent, due to fears of reprimand for exceeding environmental limits.

2.3 SUMMARY OF FACTORS CONTRIBUTING TO PROCESS CONTROL SAFETY PERFORMANCE

Process plants are socio-technical systems with many factors influencing performance, including technological factors, individual factors, team behaviour factors and organisational factors. This view is confirmed by the above review.

Treating the control room as one entity (i.e. operators and control technology as one) a safe control room is one that keeps track of the situation on the plant and responds appropriately. In the absence of the fully automated control room, operators retain a critical role. As Hollnagel (1994) summarises, operators need to understand the nature of the situation, identify relevant alternatives, choose among them and implement a solution.

From the review, the following are considered to be key performance requirements of process control operators:

- Be able to follow the condition of the process, anticipate its behaviour and hence select an appropriate control strategy (i.e. have high ‘situation awareness’);
- Be in a fit state to monitor the process (i.e. be awake and attentive);
- Be willing to take action as and when necessary; and,
- Be able to take action, reliably and within the necessary time frame.

In addition, key team performance requirements are:

- Be able to collect and share critical information about the process and control actions; and,
- Be able to co-ordinate actions.

The review identifies many factors that influence the operator and team performance, including (in alphabetical order);

- Culture (e.g. openness, team spirit);
- Experience;
- Interactions with other activities (e.g. disturbances);
- Management of change;
- Number of staff;
- Procedure design;
- Process control technology;
- Roles and responsibilities;
- Training; and,
- Working hours (including shift pattern).

Can this list of factors be considered to be complete? As is noted above, a clear message from the review is that process control activities fit into a socio-technical framework. Therefore, the assessment of control room safety can take advantage of the accumulated understanding of socio-technical systems.

Comparison of the above list of factors with those highlighted in studies of socio-technical systems, prompts the observation that control room safety will be influenced by how an organisation improves, e.g. how it reviews and learns from incidents and experience. Therefore, the list of factors identified from the review is used as a starting point in developing the assessment method but does not constrain it.

3. REVIEW OF ASSESSMENT TECHNIQUES

What techniques have been used to assess the factors summarised above? Are there other techniques that are suitable?

3.1 TECHNIQUES USED IN STUDIES OF PROCESS CONTROL

3.1.1 Workload assessment techniques

Real-time simulation of scenarios

Simulators have been used in the nuclear sector for workload assessment. The research programme into the effect of control room design and control room staffing on operator and plant performance, carried out in the Loviisa nuclear power station, Finland and Halden Man Machine Laboratory (HAMMLAB) in Halden, Norway, assessed team performance in five incident scenarios (steam generator tube rupture, sustained total loss of feedwater, loss of offsite power, interfacing system loss of coolant accident, and steam generator overfill). Scenarios were analysed in stages, with pauses to gather data and quiz the participants (Hallbert et al 1995 & 1997, Sebok 2000). Several types of data collection methods were used including videotapes, audio recordings, paper questionnaires and simulator records. Sebok summarises the findings: ‘this study provided a diverse view of crew performance in realistic process control operating conditions. The results indicate that interface type and crew staffing levels affect crew performance in a variety of ways. Anticipated changes to control room interface design and / or staffing levels need to be investigated before being implemented’.

Walk- or Talk- through of scenarios

The techniques of in-situ walk-throughs or round table talk-throughs are widely used. The latter is frequently used in the design of control rooms. Folleso et al (1992) use these methods in the assessment of process control screens.

Decomposition of tasks

In the re-design of a multi-operator control room, Plug and van der Ploeg (1999) were concerned with workload, the influence of various operating situations on the workload, the physical layout of the control room, applied technology and the commitment of the operators. They sub-divided workload into regular and random. Their approach to workload calculation was to list the activities in both categories and use observations and interviews with operators to assign durations and frequencies to them. To verify the accuracy of these lists, they referred to a printout of alarm signals from the computer system. The summation included stochastic simulation (queuing theory). They note this technique is suited to ‘normal’ operating conditions, including the occurrence of everyday problems, but is not suitable when large, unusual disturbances in the process (critical events) occur. Consequently they used a different approach for critical events and start-up and shutdown scenarios. Although not explained, they imply a scenario based, walk- or talk- through approach.

Anderson and Smith (1995) describe the methodology they followed when implementing a new control and communications system into the central and station control rooms of the Hong Kong Mass Transit Railway. They observed the existing activities and with the data constructed a Hierarchical Task Analysis (HTA) to provide a framework to determine the task steps, plans, decisions and information requirements necessary for each member of the control room team to carry out their duties. Communications were observed but team members were required to log each communication and, in addition, a set of structured emergency simulation exercises were developed and undertaken during non-traffic hours. The HTA and communication data were combined into a time-line analysis, from which a workload chart was derived. The authors claim 'workload values in the range 50 to 75% are preferred in terms of human performance' but give no basis for this.

Folleso et al (1992) applied the GOMS methodology (Goals, Operators, Methods and Selection rules) to the design of process control interfaces. It is a method that focuses on the interaction between human and computer and is a formal way of expressing the procedural knowledge an operator needs to operate a system. The authors believed they were able to reduce the mental workload involved in handling scenarios by splitting complex and ill-defined tasks into manageable ones. The analysis identified bottlenecks in the system, especially placing too large demands on the operator's ability to remember information across different screens and different tasks.

3.1.2 Individual factors assessment techniques

Self-assessment techniques

To assess factors such as situation awareness, attentiveness, error-proneness and stress, the predominant mode is self-assessment.

Kecklund and Svenson (1997) used questionnaires and diaries to collect data on work environment, work task characteristics and organisational factors, work demands, alertness, coping, and work performance quality. Questionnaires were given twice to each operator, the first concerned the annual outage (distributed at the end of the outage), the second concerned normal operations. The questionnaire focused on task characteristics and organisational factors, alertness, coping, and work performance quality. The diary was highly structured in that it contained specific questions about work demands, coping and work performance quality. Numerical answers were required, and the diary was to be completed at the end of every shift or after certain critical activities were carried out. A selection of the diary questions are given below:

- Work performance quality : Minor errors (scale 1-5 1= few errors, 5= many errors):
  - Forgot to change the indicator of component status in the process chart;
  - Was unable to remember something which I know I am familiar with;
  - Forgot what to do because someone disturbed me;
- Work performance quality : Misinterpretation errors (scale 1-5 1= few errors, 5= many errors):
  - I could not remember essential information while performing an operation and therefore I had to ask for information again;
- Work performance quality: Satisfaction with work performance (scale 1-9, 1= not satisfied, 9= very satisfied):
  - I have performed my work task with a good result;
- Work demands (scale 1-9, 1= low, 9= high)
  - High demands on performing several activities simultaneously;

– High demands on mental capacity.

Hogg et al (1995) developed a Situation Awareness Control Room Inventory (SACRI), adapted from a technique used in aviation research. The question wording is based on the concept of situation awareness as a temporal state existing with dynamic decision making. It is given to operators involved in simulations. The simulation is frozen to allow the questionnaire to be answered, giving a snapshot of the operator's awareness of the current situation. Multiple freezes allows comparison of these different snapshots as the scenario develops. At each snapshot, questions are asked that relate to the recent past situation with that of the present, the present state with that which is normal, and the present state with that which is projected into the near future. The type of questions asked are:

- In comparison with the recent past, how has the positioning of the safety isolation valves developed?
- In comparison with the recent past, how has the flow into the make-up system's let-down tank developed?

Jensen (1999) gave operators questionnaires about activities they perform to keep alert. Each activity was rated on a 100 point scale.

Attwood and Nicolich (1994) used a battery of three computer-based tasks and a 'feeling tone' questionnaire to assess alertness. The computer-based tests were performed together and consisted of a test of the operator's ability to remember simple information for short time periods (Continuous Memory test); a spatial test in which the operator must decide whether a number is presented normally or as a mirror image (Image Rotation test); and a secondary task that required the operator to monitor a dial at the top right of the screen throughout the other two tasks (Dial Monitoring). The 'feeling tone' checklist (feeling lousy to feeling great) was completed prior to each computer trial.

Other techniques

The method used for fatigue risk assessment, described by Lucas et al (1996), uses defined and quantified rating scales for six factors. An overall fatigue index can be calculated. The simplification of the method was acknowledged, in particular the additive calculation and the non-consideration of interactions between the factors. From a peer review came comments on:

- the benefits of the 'red zone' for each factor, and the suggestion for a 'concern/ warning zone' to be added;
- the wariness about users becoming over reliant on the numerical output of a risk assessment, rather than on a broader assessment of the task being carried out;
- the balance of the factors, with revised weightings proposed.

3.1.3 Team performance factors assessment techniques

Team performance is a complex issue, with many factors and influences. The approaches used to assess teams reflect this.

Ashleigh and Stanton (1996) describe a framework for analysing teamwork in control rooms that encompasses many techniques, including:

- behavioural competency scores for each individual in the team;
- analysing other biographical data;

- a human factors review to provide a measurement of the technical context of the control room, including: visual clarity, consistency, compatibility, informative, feedback, explicitness, appropriate functionality, flexibility and control, error prevention, user guidance and usability problems. The technique for this is in-depth usability study undertaken with a sample of operators, using a structured evaluation checklist;
- a link analysis for tracking physical movements of people in and out of the control room as well as monitoring demand or resources and equipment (e.g. fax/printers);
- direct observation, by shadowing operators who provide contextual information;
- self-reporting of team members perceptions of their own synergy. Seven 'teamwork' dimensions are used on a questionnaire: consensus, co-ordination, control, communication, co-operation, coaching and culture;
- questionnaire on life and job satisfaction; and
- rating of team output against the company's own operating philosophy.

Hallbert et al (1995) used the Behaviourally Anchored Rating Scale (BARS) technique for team performance appraisal where they selected dimensions of team interaction from: communication, cooperation, openness, task coordination, team spirit, maintaining task focus, adaptability, acceptance of criticism, giving criticism. As noted earlier, this study involved extensive data collection and no doubt extensive interpretation.

In a review of teamwork in multi-person systems, Paris et al (2000) comment that no single measure of performance will be appropriate for all purposes. They consider the primary types of measures to be:

- descriptive measures, which describe what is happening at any given time and seek to document individual and team behaviours by highlighting crucial points of interaction and moment-to-moment changes in team functioning;
- evaluative measures, which judge performance against identifiable standards and serve to answer questions of effectiveness;
- diagnostic measures, which seek to identify the causes of behaviour and question how and why things occurred as they did.

They note that measurement approaches for team evaluation range from developing / applying critical events or event based techniques to modelling human performance via expert systems, neural networks, fuzzy sets or mathematical models. Data may be captured online by observers or via automated systems. Instruments include rating or event-based scales, observational checklists, critical incident analysis, communication analysis, employee surveys and debriefing procedures. The conclude that while progress has been made in designing measurement techniques and tools, more work is needed, and the current focus on checklists, while useful, does not capture fully the dynamic nature of teamwork.

3.1.4 Assessing control room technology

O'Hara, Stubler and Kramer (1997) used, in their assessment of the implications of developing control room technologies, seven questions from 'guidance on licensing digital upgrades' (EPRI 1993):

- May the proposed activity increase the frequency of occurrence of an accident evaluated previously in the Safety Analysis Report (SAR)?
- May the proposed activity increase the consequences of an accident evaluated previously in the SAR?
- May the proposed activity increase the probability of occurrence of a malfunction of equipment important to safety evaluated previously in the SAR?
- May the proposed activity increase the consequences of a malfunction of equipment important to safety evaluated previously in the SAR?
- May the proposed activity create the possibility of an accident of a different type than any evaluated previously in the SAR?
- May the proposed activity create the possibility of a malfunction of equipment important to safety when the malfunction is a different type than any evaluated previously in the SAR?
- Does the proposed activity reduce the margin of safety as defined in the basis for any technical specification?

3.2 OTHER TECHNIQUES SUITABLE FOR ASSESSING STAFFING FACTORS

Two categories of techniques not referred to explicitly in the literature, but considered to be candidates are management auditing and structured safety assessment methods. The latter includes the HAZard and OPerability method (HAZOP), Failure Mode and Effects Assessment (FMEA), Fault and Event Tree analysis (FTA and ETA).

3.3 APPRAISAL OF ASSESSMENT TECHNIQUES

The above review has thrown up nearly a dozen techniques. These are now appraised and narrowed to a set of suitable techniques on which the method could be based.

Appraisal criteria

Each technique is appraised against six parameters:

- Relevance to the problem at hand;
- Maturity;
- Ease of use;
- Resources required;
- Expected variability in results when applied; and
- Transparency of results.

Findings

The appraisal is given in Table 3.1. In summary:

- Simulation and real-time observational methods are time consuming, difficult to interpret and can be disruptive (high work load, abnormal conditions with low frequency of occurrence but potentially large consequences are not likely to be observed);

- Giving operators self-assessment questionnaires, perhaps in the form of a diary, does appear to be feasible, but could be prone to bias due to organisational cultural factors (openness, blame culture etc). There could be scope for using such methods to tune operators into the issues in the lead up to the analysis using other methods;

- Task decomposition methods, including link analysis, face problems in analysing scenarios with uncertainty, into which process upsets and emergency incidents would be grouped;

- Walk- or talk- through methods are intuitive and familiar techniques;

- Structured hazard assessment methods are now widely used, accepted and adaptable. Attempts have been made to adapt them to examine human factors. No version tailored to staffing issues has been found;

- Management auditing is a mature technique. The personal experience of auditors is an important part of the process;

- Anchored rating scales are growing in popularity and straightforward to use (e.g. the Business Excellence Model from the European Foundation for Quality Management, and a safety culture matrix based on the Business Excellence Model produced for HSE by Entec (2000)). Scales can be tailored. The versions referred to in the literature are designed to examine a sub-set of staffing factors.

Conclusions

Several of the methods described in the literature are suited to research rather than to routine use as hazard assessment tools.

Given the aim to have the method widely used, and that it is suspected many organisations in the chemical and allied sector have made little progress in assessing staffing factors, the most promising route is to start with techniques that are familiar to the sector or are gaining favour. Therefore, three techniques stand out:

- Structured hazard assessment methods, such as HAZOP, FMEA, fault / event tree analysis;

- Walk- or talk- through methods;

- Anchored rating scales.

Table 3.1 Appraisal of methods

Techniques	Technical factors	Individual factors	Team factors	Org and Mgt factors	Maturity	Ease of use	Specialist skills or resources required	Variability in results	Transparency of results (e.g. 3rd party can review)	Comment
Anchored rating scales	(✔)	✔	✔	✔	High	High	No	Low	High	Very adaptable. Dependent on quality of anchors
Diary (with structured questions)	✔	✔	✔	(✔)	Low	Medium	No	Medium	Low	Suitable for a sub-set of factors
Direct observation of operations		✔	✔		Low	Low (difficult to analyse)	Yes (observer)	High	Low	Raises 'obvious' issues, but not rigorous
Ergonomics checklist	(✔)	✔			Medium	Medium	Yes (analyst)	Medium	Medium	Many checklists available
Link analysis	(✔)	✔	✔		Medium	Medium	Yes (analyst)	Low	Medium	Good for layout & communications per scenario
Management system audit				✔	High	High	No	Low	High	
Operator self-assessment questionnaires	✔	✔	✔	(✔)	Low	High	No	Medium	Low	Similar to diary
Real-time simulation		✔	✔		Low	Low (requires a simulator)	Yes (simulator, analyst)	Medium	Low	Few companies have simulators

Techniques	Technical factors	Individual factors	Team factors	Org and Mgt factors	Maturity	Ease of use	Specialist skills or resources required	Variability in results	Transparency of results (e.g. 3rd party can review)	Comment
Structured hazard assessment methods (e.g. HAZOP, critical event analysis)	✔	✔	✔	(✔)	High (for technical) Low (for others)	Medium	Yes (facilitator)	Medium	High	Systematic (Not flexible). Can be high level or very detailed. Best if multidisciplinary. Can drift off topic when used for human factors
Task decomposition methods		✔	✔		Medium	Medium	Yes (analyst)	Medium	Medium	Can support training needs analysis and procedure assessment
Walk- or Talk- throughs		✔	✔		Medium	Medium	Yes (facilitator)	Medium	Medium	Can be very detailed. Good at involving operators

(✔) secondary factors

4. SPECIFICATION OF THE STAFFING ASSESSMENT METHOD

4.1 SPECIFICATION

The specification of the assessment method is set out in the form of requirements as follows:

- support duty holders in their obligations to assess and manage risks;
- focus on process risks, in particular loss of containment events that have off-site impact potential;
- bring staffing issues into the open, by making plain which staffing factors have a bearing on process safety;
- be valid for the operational circumstances found in the chemical and allied industries;
- enable duty holders to obtain a clear cut indication of whether their staffing arrangements are unsafe;
- enable duty holders to gauge the impact of staffing changes, particularly reductions, prior to implementation;
- enable duty holders to review how staffing arrangements may have contributed to incidents;
- be able to be taken up widely:
  - self-contained, with necessary guidance;
  - practical, useable and intelligible to duty holders and inspectors;
  - non reliant on specialist skills, competencies, or reference to costly databases;
- be robust and resistant to manipulation and massaging of its output;
- be structured and auditable; and,
- facilitate informed dialogue between duty holders and inspectors about staffing arrangements.

4.2 THE VARIETY OF OPERATIONAL CIRCUMSTANCES

It is recognised there is no standard configuration of how processes are controlled. Situations observed include:

- several operators within a control room running one or several process units;
- one control room operator working on his own spending all his time within the control room;
- one operator, who performs tasks in the field and in a control room;
- a field operator may come in to the control room to assist the operator during process upsets;

- the control point may be unmanned for a period, with unacknowledged alarms diverting to a remote control point; or,
- controls may be dispersed on panels around the plant.

The method should tolerate all of these circumstances.

5. DESCRIPTION OF THE METHOD

5.1 OVERVIEW OF THE METHOD

The method concentrates on the staffing requirements for responding to hazardous incidents. Specifically, it is concerned with how staffing arrangements affect the reliability and timeliness of detecting incidents, their diagnosis and recovery to a safe state.

The method takes a socio-technical perspective, i.e. it is grounded on the understanding that effective control is dependent on technical, individual and organisational factors. Therefore, to assess staffing arrangements the method must evaluate relevant technical, individual and organisational variables.

The method is designed to flag when too few staff are being used to control a process. To apply the method working arrangements and task allocation must be defined before being tested using the method. Therefore, the method is not designed to calculate a minimum or optimum number of staff.

If a site finds that its staffing arrangements ‘fail’ the assessment, it is not necessarily the case that it must increase its staff numbers. Other options may be available, such as redistributing tasks, modifying procedures or upgrading control technology.

Not only does the method assess staffing numbers, it also examines how staffing arrangements are managed.

The method is presented in full in appendices A & B.

5.1.1 Appraisal approach

Appraisal of technical factors

In evaluating technical factors the focus of attention is whether the design of the process control equipment (e.g. control room) and support equipment (such as mobile communication equipment) allow incidents to be detected, diagnosed and responded to in time. It is the inherent safety of the design and layout of controls and equipment that is in question. Concerns over whether operators have the training or authority to carry out tasks are examined later.

Because of the type of questions evaluated in the technical assessment it is referred to as the ***physical assessment***:

- Is the layout of the plant and control room such that a person can move around them in the time required?
- What happens if operators cannot reach a control in time, perhaps due to them stumbling and injuring themselves in the field?
- Does support equipment, such as radios and pagers, have sufficient reliability?

The physical assessment is in the form of a systematic and structured analysis. It is founded on widely used hazard identification and assessment techniques such as HAZard and OPerability studies (HAZOP), Event Tree analysis and walk- / talk- through methods, but has been given a firm structure to help analysts focus on relevant hazards.

Appraisal of individual factors

A major concern is whether operators have the knowledge and capabilities to detect, diagnose and respond to incidents in time. This includes whether support staff can attend in time and work together to return the situation to safety.

The assessment is in the form of seven anchored (descriptive) rating scales, referred to as *ladders*. These are straightforward to use and self explanatory. They set out an ascending scale of descriptive anchors, from poor practice up to best practice, allowing an organisation to identify where it sits on the ladder and what it can do to improve.

Appraisal of organisational factors

Policies and procedures that have a bearing on staffing are examined. This includes the management of operating procedures, management of change and continuous improvement. The anchored descriptive rating scale technique is used, and four ladders have been produced.

5.2 DETAILS OF THE ASSESSMENT METHOD

5.2.1 Details of the physical assessment

The physical assessment tests the arrangements against six 'principles':

vii) There should be continuous supervision of the process by skilled operators, i.e. operators should be able to gather information and intervene when required;

viii) Distractions such as answering phones, talking to people in the control room, administration tasks and nuisance alarms should be minimised to reduce the possibility of missing alarms;

ix) Additional information required for diagnosis and recovery should be accessible, correct and intelligible;

x) Communication links between the control room and field should be reliable. For example, back-up communication hardware that is non-vulnerable to common cause failure, should be provided where necessary. Preventive maintenance routines and regular operation of back-up equipment are examples of arrangements to assure reliability;

xi) Staff required to assist in diagnosis and recovery should be available with sufficient time to attend when required;

xii) Operating staff should be allowed to concentrate on recovering the plant to a safe state. Therefore distractions should be avoided and necessary but time consuming tasks, such as summoning emergency services or communicating with site security, should be allocated to others.

The assessment is in the form of specific questions, each requiring a yes/no answer. The questions are arranged in eight trees (an example is given in Figure 5.1), some or all of which will be relevant to a plant. The first three trees deal with the ability to detect problems in time, the remaining five test the ability to diagnose and recover from problems in time. The questions seek to establish the following:

- Could a principle be infringed?
- Define how it will be infringed;

- What measures are in place to compensate for the infringement?
- Are the measures adequate?

The analyst should use risk based arguments when judging whether a measure is adequate, e.g. give consideration to whether the failure rate is as low as reasonably practicable. By doing so the analyst will judge whether the arrangements do or do not infringe any of the principles.

Supporting evidence

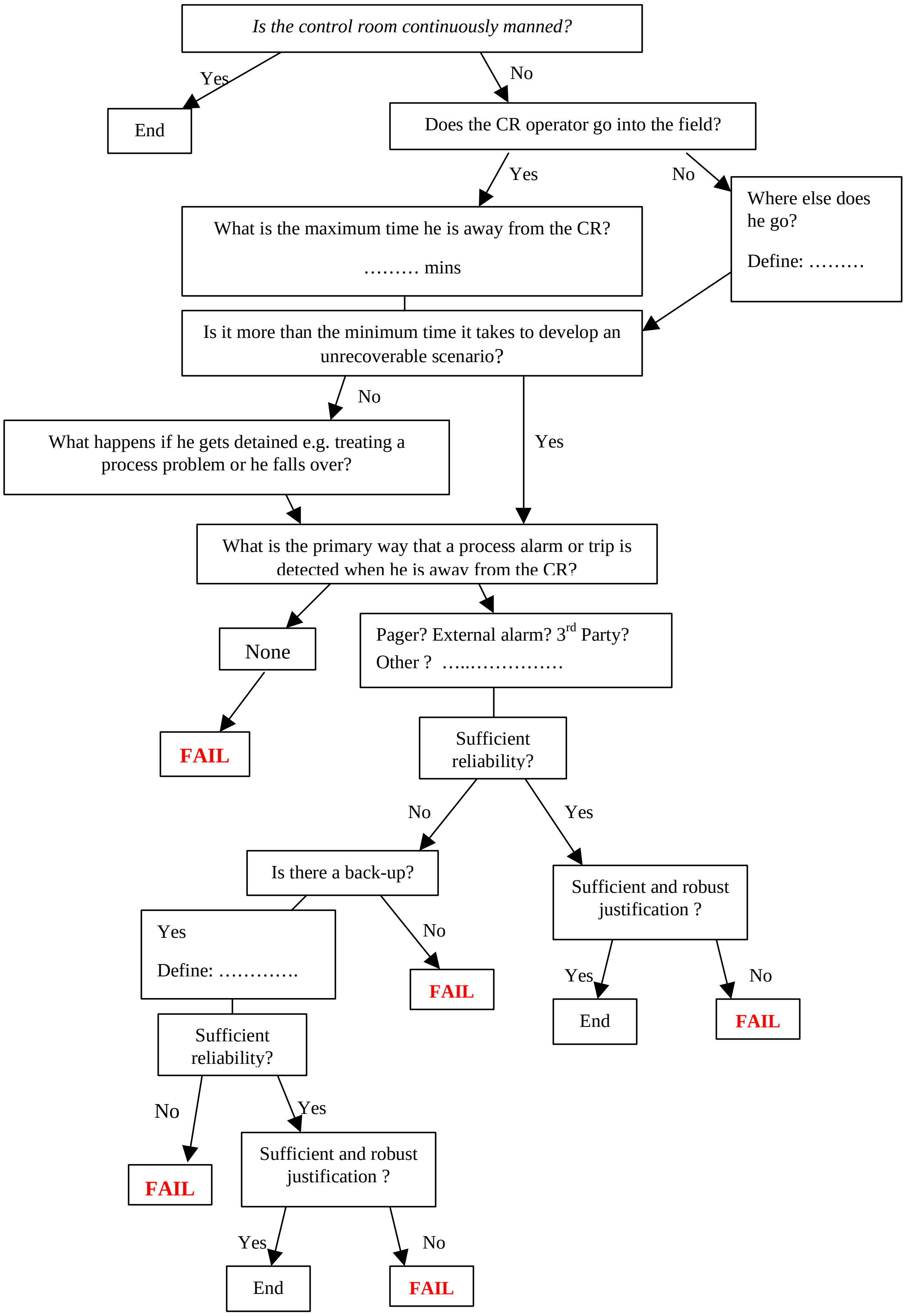
To complete the physical assessment, various forms of supporting evidence should be prepared or referenced. Examples include:

- Calculations of the time available to respond to process incidents;
- Data from previous incidents and/or observations from 'real time' exercises (e.g. to gauge the time for operators to perform tasks);
- Reliability assessments for critical equipment;
- Alarm records.

Performing the physical assessment by scenarios

A set of hazardous scenarios should be identified and defined, and each analysed using the physical assessment trees. It may be necessary to analyse a scenario across different shifts, or time of year, in order to test all staffing arrangements. Further guidance on performing the assessment is given in sections 7 and 8.

Figure 5.1 Example Tree from the Physical Assessment



5.2.2 Details of assessing individual and organisational factors

- The individual and organisational factors are assessed using the technique of *anchored descriptive rating scales*. The individual and organisational factors have been expanded to a total of eleven elements and for each a *ladder* with qualitative, descriptive anchors descriptive has been produced (from 'best practice' at the top to poor practice at the bottom). An analyst can position a plant on the ladder by comparing its arrangements to the descriptions in the anchors. An example ladder is shown in Table 5.1 (note: the dotted line represents the boundary between acceptable and unacceptable).

Table 5.1 Example ladder (for training & development)

Grade	Description	Explanation of progression	Rationale supporting assessment
A	**Process/procedure/staffing changes** are **assessed** for **the required changes** to operator **training and development** programmes. **Training** and **assessment** is provided and the **success** of the **change** is **reviewed** after implementation.	The training and development system is dynamic and integrated into the management of change process.	
B	**All operators receive simulator or desktop exercise training** and **assessment** on **major hazard scenarios** on a **regular basis** as part of a **structured** training and development **programme**.	Operators get a regular opportunity to practice major hazard scenarios through physical walk through's or simulators or by desk-top talk throughs.	
C	There is **a minimum requirement** for a **'covering' operator** based on **time per month** spent as a **CR operator** to ensure **sufficient familiarity**. Their **training and development** programmes **incorporate** this requirement.	It has been recognised that anyone covering the control room must be competent and their skills kept up to date.	
D	**Each operator** has **a training and development plan** to progress through **structured, assessed skill steps** combining **work experience** and **paper based** learning and training sessions. **Training needs** are **identified** and **reviewed regularly** and **actions** taken to **fulfil needs**.	The training and development needs are identified, provided and reviewed on an individual basis allowing operators to improve and extend their skills and understanding. It provides operators with a motivation to improve and continue to develop.	
W	**All operators** receive refresher training and assessment on **major hazard scenario** procedures on a **regular, formal** basis.	The need for formalised regular refresher training for major hazard scenarios has been recognised as essential when they are such infrequent events with severe consequences.	
X	**New operators** receive **full, formal induction training** followed by **assessment** on the process during **normal operation** and **major hazard** scenarios	Full training and assessment for new operators, it is formalised and covers normal operation plus major hazard scenarios.	
Y	There is an **initial** run through of **major hazard** scenario procedures by **peers**.	Only an informal briefing on major hazard procedures is provided to new operators.	
Z	There is **no evidence** of a **structured** training and development programme for operators. Initial training is **informally** by peers.	Poor practice, staffing arrangements do not fulfil any of the rungs above.	

Supporting evidence

As with the physical assessment, the ladder assessments should be supported by evidence. In the case of the individual and organisational factors the forms of evidence sought include:

- Views and experiences of control room operators, other operators, managers, support staff;
- Documents such as operating procedures for normal and emergency situations, job descriptions, safety policy, company literature, training records, safety performance reports, safety audits;
- Information on training plans, occupational health monitoring; disciplinary records; and,
- Reports on past incidents.

Table 5.2 Summary of the assessment method

Factor	Element	Assessment method	Summary
Technical factors	Physical assessment	Structured hazard assessment trees	Is it possible to detect, diagnose and recover from scenarios leading to major hazards? Aims to give yes/no on the feasibility of physically dealing with each scenario in time.
Individual factors (Workload)	Situational awareness	Descriptive rating scale	Quality of knowledge on current and near future situation. Is it possible to carry out all required monitoring checks in the time available? Includes short term disturbances such as permitry. Covers shift handover and monitoring conditions over a week and re-familiarisation after long breaks.
	Teamworking	Descriptive rating scale	Are there support staff available, possibly from outside the control room (role of outside operators) to assist when there is above normal activity? Are the roles and procedures defined?
	Alertness & Fatigue (split into *working pattern* and *health*)	Descriptive rating scale	Use of health programmes to monitor possible symptoms of stress. Shift pattern effects on operator fatigue. Sickness rate amongst operators may indicate problems. Includes effect of lighting, temperature on alertness.
Individual factors (Knowledge and skills)	Training and development	Descriptive rating scale	For new operators and to refresh existing operators, particularly for major hazard scenarios.
	Roles and responsibilities	Descriptive rating scale	Are they clearly defined? Is the team composition defined and based on a structured assessment? Is this reviewed before a possible change to ensure core competencies are maintained?
	Willingness to act	Descriptive rating scale	Extent to which operator actions can be influenced by factors such as cost and environment over safety
Organisational factors	Management of operating procedures	Descriptive rating scale	System for updating procedures, validating and implementing (including training).
	Management of change	Descriptive rating scale	Use of transitional techniques to ease the change whether, people, technology or procedures. Extent of training. Checks in place after a change to review the effects.
	Continuous improvement of safety	Descriptive rating scale	Monitoring of product quality, appraisal for operators to allow continuous improvement. Use of on-site and off site historical incidents to improve performance. Continuous improvement initiatives in place.
	Management of safety	Descriptive rating scale	Strength of site policy, use of historical data to improve performance, workforce involvement.

6. PILOTING AND TRIALING THE METHOD

6.1 INTRODUCTION

The assessment method has been piloted with HSE inspectors and trialed at two companies. The trials were undertaken jointly by Entec and site staff.

Neither the piloting nor the trialing were full applications of the method. The prime objective was to assure the method can be applied and that it produces credible findings. In particular only a fraction of scenarios were analysed using the physical assessment trees and where reliability of systems were unknown, no analysis was undertaken.

The objectives and lessons learnt are described below.

6.2 OBJECTIVES

The objectives for testing the method were:

i) To gain feedback on the assessment elements:

- Are they applicable?
- Are there any omissions?

ii) To gain feedback on the assessment techniques:

- Ease of use;
- Whether the method is objective or subjective;
- Whether the assessment outcome could be massaged;
- The degree of ambiguity;
- Whether the logic of the physical assessment was understandable and defining the basis for deciding which branch to take;
- Whether the ladder rungs are sequential and reflect a step wise progression from poor practice to best practice.

iii) Evaluate the method as a self assessment tool for sites:

- Resources required to complete the assessment in terms of the number and background of participants plus the time required per person and in total;
- Whether sites have the skills on site to be able to complete the assessment;
- The best way to apply the method on site;
- Identifying areas within the method which require clarification or better definition.

6.3 PILOTING WITH HSE INSPECTORS

The piloting with HSE Inspectors was used to fulfil the first objective, gain insight into the second and obtain their thoughts on the third.

The Inspectors reacted positively to the style and content of the assessment method. The progressive steps in the ladders were particularly liked.

Some general comments made by inspectors were:

- If sites did not undertake the analysis themselves, the success of inspectors going through the method would depend on the company being fully briefed as to expectations. Otherwise an inspector would get only half a picture or an unvalidated whole picture.

- Sites at which there were concerns over staffing could be requested to apply the assessment, and used it as a basis for discussion.

Points raised by the Inspectors were used to refine the method prior to applying it at the case study sites (see section 6.5).

6.4 CASE STUDIES

The case studies were used to evaluate the method and thereby fulfil the above objectives.

Approach

Each case study took place over four days. All parts of the assessment method were trialed at each site, but only a sample of scenarios were examined. A full assessment would require more time, not only to analyse further scenarios but to document the assessment.

One-to-one interviews with operators to complete the physical assessment for two or three scenarios. Each scenario was talked through in terms of the actions required and the people responsible and then the relevant physical assessment trees were worked through.

The ten ladders were assessed by:

- One-to-one interviews to go through between one and three ladders in detail per person;

- Independent assessment by staff without the Entec facilitator;

- Group sessions to review the assessment of all ladders.

Each participant was given a half hour explanation of the assessment method prior to assessing any element.

Overview of the case study sites

The assessments of the case study sites are given in Appendices C, D and E. Case study 1 (Appendix C) includes a worked example of the physical assessment (with notes at key decision points) and ladder assessments are included (including summarised answers to the ladder questions) as well as supporting information gained during the visits. Case studies 2 and 3 (Appendices D and E respectively) include summary tables of the assessment output including recommended improvement actions. The method presented in the case studies does not incorporate the latest changes to the ladders which were suggested from the industrial seminar.

The first case study site was a greenfield site when built about ten years ago. There are approximately 50 people on site. There is one control room for two continuous process trains.

The major hazards for the site are natural gas leaks and the potential for fire and explosion. The site is surrounded by other major hazard sites and hence must be able to deal with an emergency originating off site.

The second case study site has operated since the 1930's although the plant and processes have been changed and upgraded and there have been several changes of ownership. There are several control rooms and operating units on site and approximately 300 people in total. Two control rooms were assessed, one controls two continuous process units, the other controls a single batch unit. The major hazard for the site is toxic gas release. As with the first case study site it is surrounded by other major hazard sites and must be able to deal with an emergency caused by an off site event.

6.4.1 Lessons from the trials

The trials shed light on how the method can be applied and on how it compares to other safety appraisal methods.

Lessons on applying the method

Lessons on the following emerged from the collaborative case studies:

- Resourcing needs:
  - the key people to involve in terms of independence, experience, roles and skills;
  - the mix of skills required;
- The time to be allowed for key stages of the assessment;
- The type and number of scenarios to be analysed within the physical assessment and how tightly defined each scenario should be.

Resourcing needs

For both case study sites, the control room operators completed the physical assessment trees. When other site employees were asked whether they could complete them they judged they did not feel sufficiently 'close' to the control room operation to do so. This was also the reply from those that had been control room operators a few years ago.

The ladder assessment elements required a wider range of participants to capture the range of knowledge and experience required. Control room operators provided the bulk of information and support and management staff provided additional information for the various sections. Depending on the site organisational structure, each element will require a different member(s) of support or management staff to participate along with control room operators, other shift team members and the shift team(s) line manager. Participants found it easiest to read the ladders from the bottom up.

As the method is designed as a structured systematic assessment tool, it is important that the whole process is managed consistently by an objective, independent person. The case studies strongly identified the need for a facilitator to fulfil this role who would ensure the method is adhered to and that the assessment team are guided through the process to explore problem areas.

Time requirements - Physical assessment

When analysing each scenario on a one-to-one basis the physical assessment trees took between 5-30 minutes depending on the similarity to other scenarios and the familiarity of the interviewee with the decision trees. After the first use of the trees, operators became adept at following the logic. The only challenge was to ensure they kept to a specific scenario as they had a tendency to drift towards the general situation. An initial talk through of each scenario prior to the assessment helped combat this. Therefore, it is estimated that if a group format were used (similar to a HAZOP session) approximately forty five minutes should be allowed per scenario to talk it through, refer to background data such as incident reports, make the necessary calculations such as time available in an incident, and complete the trees.

Time requirements - Ladder assessment

Each ladder assessment took between 5-30 minutes per person depending on the assessment element and the extent of the site's controls for a particular element. The questions were easily answered by operators, managers and support staff. The objectives underpinning some of the ladder rungs required further explanation. It is estimated that each of the ten elements would take an assessment team approximately an hour to discuss and complete (including referring to documented or physical evidence as much as possible).

Type of scenarios to be analysed

The physical assessment should cover sufficient scenarios to ensure that a site is able to cope with any foreseeable situation. There is scope for identifying 'families of scenarios' and assessing two to three representative scenarios from each group (ensuring that the worst case in terms of consequence and operator workload is covered).

One approach to grouping scenarios is as follows:

- Worst case scenario requiring implementation of the off-site emergency plan;
- Incidents which could escalate without intervention to contain the problem on site; and,
- Lesser incidents requiring control room reaction to prevent the process becoming unsafe.

Each scenario needs to be defined in sufficient detail. As a minimum:

- Define who is controlling the process and their starting locations;
- Define who is available to support the incident, and their starting locations, and,
- Define the parameters that determine the time available to the operations team for detection, diagnosis and recovery. Therefore parameters such as process conditions, leak point, wind direction, release rate, time of day, need to be defined.

Sites will need to consider whether they should assess a scenario at different times if their staffing arrangements vary, such as during the day and at night, during the week and at weekends.

Observations on how the method compares to other safety appraisal methods

Experience gained during the collaborative case studies suggests the method covers many issues which are not assessed by existing methods such as HAZOP and risk assessment. This particularly applies to the elements covered by the ladder assessments but also to the physical assessment as it is assessing the reality of control room operation rather than a frozen P&ID or operating procedure. It also generates greater insights due to control room operators providing the majority of the assessment input which is often not the case with other assessments.

For example an issue that arose at one site was what a contractor would do if he had caused a toxic gas leak and went to the batch process control room to report it and the control room operator was not present (which is likely as he works alone and can be outside in the plant).

At the site safety induction contractors are instructed to contact site security on detection of toxic gas. The physical assessment trees identified this as a critical action, since if a contractor tried to locate the operator instead the scenario could develop into an incident with off-site impact. Two contractors were quizzed on what they would do in that particular situation and correctly replied that they would contact security. However to ensure all contractors would act correctly the control room operator and site Health and Safety advisor involved in the assessment identified additional actions such as a reminder notice in the control room plus incorporating the situation as a question to ask contractors on the site weekly audits.

The assessment cross-validated findings from other hazard and risk assessment methods. The physical assessment on the batch control room (Appendix D) identified areas of unacceptable risk which had been identified during a recent area HAZOP. The problems were associated with lone working and how process alarms or a toxic gas leak would be detected during a night shift if the control room operator (who has no support team) is incapacitated.

One of the sites had recently been audited by a corporate team. This had covered matters including, auditing, emergency planning and response, management of personnel change, incident investigation, contractors, and training and performance. Consequently the audit had looked at some of the topics covered by the staffing assessment method, in particular it had overlapped with some of the ladder elements, but on a site wide basis. It did not overlap with the physical assessment approach. Some of the issues identified by the staffing assessment method had been picked up by the corporate audit, such as training and development. Of course the staffing assessment was focused on part of the site, while the audit was site wide. Nevertheless, the site Health and Safety Advisor commented that in comparison to the audit, the staffing assessment 'got inside people's heads' and both the anchors and physical assessment trees provided discrete measures to gauge themselves and set targets to aim for.

6.5 ENHANCEMENTS TO THE METHOD

The piloting with inspectors and case studies identified enhancements to the method. The majority of the improvements came from piloting with inspectors as expected due to it being the initial test of the method. The improvements to the physical assessment are summarised as:

- Improvements to the logic at several points in the physical assessment trees to make them easier to follow;
- Signposting next steps in the physical assessment trees at the end of every branch;
- Providing a safe process trip option as well as an unsafe process trip;
- Defining what is meant by equipment failure and what controls are required to provide a basis for assuming that back-up equipment will not fail;
- Making the required probability of success *feasible* rather than *possible*, and needing to make failure rate as low as reasonably practical;
- Asking for the *maximum* time a control room operator is away from the control room or console rather than the *typical* time;
- Making it clear that recovery is to a safe state; and,

- Defining what a major hazard scenario is.

The enhancements in the assessment ladders from piloting with inspectors were:

- Adding into the training and development ladder, the need for assessment after training;
- Adding a rung into the training and development ladder for new operators to get full, formal induction training on the process during normal operation and major hazard scenarios;
- Including authority within the willingness/attitude ladder, whether operators need to let management know before they act, either feel the need or think they are expected to ask management i.e. degree of autonomy;
- Within the willingness/attitude ladder, include how the difficulties associated with start-up may influence a shutdown decision; (There may be intermediate measures, e.g. if action is taken early to initiate recovery it may only involve a turn down or recycle mode rather than shut-down).
- When interviewing operators for the willingness/attitude, explain that the method is looking at whether the costs are common knowledge or whether they have been communicated through training or briefing i.e. implicitly or explicitly known;
- Adding to the procedures ladder, pro-actively sharing information between production units on a site and sites within a company or others with similar processes;
- In the management of change ladder, review how a site can progress from assessing the safety implications of the change to reversing the change if safe control room operation is compromised. A site must also build a 'change team' with the appropriate skills;
- In the management of safety ladder, targets for safety should be written into individual job plans, if not for the operators then certainly for supervisors or management;
- Ensure that ladder rungs make one or two points each as the more issues covered by each rung the more difficult the ladder is to use.

The enhancements arising from the case studies have been in the presentation of the physical assessment and ladder assessments and the guidance required. In particular the case studies highlighted the areas of the method requiring more explanation and further definition. The main issue for the physical assessment was the scenario definition (explained above). The sites also suggested enhancements to the ladders in terms of rung progression and wording and again on guidance about what controls and practices the ladders were seeking to assess.

6.6 FEEDBACK FROM INDUSTRIAL SEMINAR

An industrial seminar was held on 11th September 2000 and was attended by 19 representatives from the process industries, a representative from a contract organisation and a representative from the Chemical Industries Association. The industry representatives were mostly Health and Safety managers with a few Operations managers.

The feedback questionnaire used for the seminar is given in Appendix F and contains the compiled responses from 17 delegates. The comments received under the main questionnaire headings are summarised below.

Feedback on the method

- The “ladder” principle is an easy concept to work with.
- Few guidelines required and definitions. Maybe some sort of % score that gives an indication of grade.
- The ranking of ‘rungs’ on the ladders does not always fit particular situations.
- The principles are easy to understand, but I feel that certain areas (e.g. physical assessment trees) require more explanation.
- Seminar information pack did not give enough detail on ‘trees’.
- Confusing early on but discussion in workgroups helped. The method may need to be made more reader friendly.
- The method is easy to understand as long as the definitions of what you are assessing are clear.
- Discussion with other attendees identified that task analysis may add benefits to the overall assessment process.
- It is a proactive approach to manning levels.
- I understood the main objectives once the control room definition was explained.
- Technical, individual and organisational factors all have an input into overall control room / operator interactions especially on COMAH sites.
- Uncertain whether the assessment method fully addresses identification of areas of unacceptable risk in staffing arrangements.
- Need guidance on where the assessment is on ‘ALARP’ - HSE should provide this input.
- Need to see the whole process in “live” situation to be able to comment on its ability to identify areas of unacceptable risk in staffing arrangements.
- The method does not simply identify areas of unacceptable risk but is also looking for continuous improvements when looking at the ladders.
- Believe the method could be of benefit.
- I would like to apply the method on site following more training on the method.
- Will Entec provide skilled facilitators if requested?
- The method would seem to fit into the work that is already in progress.

Feedback on the guidance

- The guidance would benefit from better definitions of some terms used.
- It is difficult to assess the guidance fully without attempting a review.
- There is a lot of detail to fit in at a one day seminar.
- The published material is very useful.

- Some clarification of the method is needed. This would be clearer with further study of the guidance.
- The guidance is understandable and easy to follow but definitions could be clearer.
- I would feel comfortable applying the method on my site but would require assistance from a resource point of view and a "pilot study" would be helpful.
- I need to discuss the method in more detail with operational staff.
- Have Entec thought of providing training on the methodology?
- I would feel comfortable applying the method on my site but believe in the first instance, external guidance would be useful to make sure we are on the right lines.
- A wider workgroup session (perhaps a day) would provide me with greater confidence before presentation to management.
- Other employees within my company may need guidance. Will there be any training courses?
- I see the role of facilitator as key in this process. Training of facilitators is critical. What suggestions do you have for this training?
- If I had a site (CIA representative), I would need more training, given that only a sample of documentation was considered.
- I would like clearer definitions e.g. job description - what should be included?; operating procedures - what should be there for a manual plant and an automatic plant?

Additional comments

- Very good seminar. The case study exercise was very useful to the company and very useful for COMAH demonstrations. It also gave an insight into potential problems and the need to produce an action plan to remedy them.
- The workshop session was extremely useful and enhanced understanding of the ladders and the method.
- The system as presented is very subjective and dependent on the auditor. Some form of scoring would be very useful.
- A very interesting day. Thank you.
- The seminar was very useful and constructive. The material that was presented gave a good overview of the method.
- Some best practice examples on issues assessed would be useful or a contact list of where best practice can be found.

A workgroup session was held on the ladders in the afternoon and each workgroup assessed four or five ladders against the questions:

1. Is it a reasonable progression from poor practice to best practice?
2. Is the acceptable line a fair and realistic target?

The feedback from the workgroups is summarised below:

- Some delegates thought the position of the acceptable line on ladders too high; others thought it too low; many agreed with its position.
- There were some suggestions for changing the order of progression on particular ladders but these were not consistent across delegate groups and many agreed with the existing ladder progressions.
- There were some suggested wording changes which have been incorporated.
- Several delegates suggested that stress should be referred to in the occupational health monitoring suggested in the ladder on alertness and fatigue (health). Monitoring for chronic stress is now included within this ladder element.
- Some delegates identified changes that they would implement in their procedures when they returned to their operating sites after reading the ladders; particularly the need for review after making changes which is identified in several of the elements.
- The need for an introduction to each ladder was identified so that the essential objectives for each element were highlighted (this was also identified during case studies). The ladder elements in Appendix A each have an introductory paragraph.
- It was suggested that it may be helpful to highlight key text in the ladder rungs. This has been incorporated.
- There was some difficulty in delegates attempting to assess the ladders without having read the preparatory questions (in conjunction with the use of documentary evidence) and therefore understanding the context and lead up to the ladders.
- The importance of workforce involvement in progressing up the ladder was understood and appreciated by some delegates more than others. This reinforced the need for an introductory paragraph to each ladder element explaining the important aspects which the assessment requires for progression.
- Some delegates were keen on having a scoring system associated with the assessment. This was deliberately not done due to the possibility of good performance in some areas masking poor performance in others and the difficulty and problems associated with trying to weight different elements. This was explained to the seminar participants.

7. GUIDANCE ON PERIODIC ASSESSMENTS OF STAFFING ARRANGEMENTS

7.1 INTRODUCTION

Good practice will be to apply the method in full initially and to review and reapply the method periodically.

This section gives guidance on applying the assessment method, in terms of the resources to involve, the procedure to follow and support information to refer to.

As a general point, it is recommended that the staffing assessment be managed in a similar vein to other process safety assessments, such as HAZOP studies or risk assessments supporting a safety case.

7.2 RESOURCES

Co-ordinator/facilitator

The assessment should be co-ordinated and facilitated by one person who is technically capable, has appropriate Human Factors skills and has experience of applying hazard identification and risk assessment methods.

The role is similar to that of HAZOP chairperson. Therefore it is good practice for the facilitator to be independent of the operations team and line management.

The facilitator's role is to:

- guide the selection of people participating in the assessment to ensure a multidisciplinary team with the correct mix of skills and knowledge;
- gather historical incident data plus document evidence for the assessment;
- brief those involved in the assessment plus senior site management as to the purpose of the assessment and the overall method;
- identify scenarios for the physical assessment with a suitable site representative such as Health and Safety Advisor (prior to finalising with the physical assessment team);
- guide the members of the assessment team through the method and facilitate the analysis. The facilitator should encourage relevant discussion and guide the team to explore problem areas without unduly influencing the assessment outcomes;
- plan and manage the assessment sessions. It is recommended they last no more than three hours;
- set out the assessment timetable;
- ensure the findings are recorded and the actions assigned; and,
- ensure there is a process for following through and completing actions.

It may be helpful for a technical secretary to be appointed, responsible for administration and assisting the facilitator in planning, arranging, running and following up assessment sessions.

Assessment team

For the physical assessment, the team should include:

- control room operators. It is recommended that both experienced and inexperienced operators be involved, and operators from different shift teams (in order to gauge the potential range of responses);
- staff who would assist during incidents, perhaps in giving technical advice to operators or with tasks such as answering phones; and,
- management or administration staff with knowledge of operating procedures, control system configuration, process behaviour, equipment and system reliability, and safety (including risk assessments and criteria).

A total of between five and ten people is recommended.

For the ladder assessment, it is recommended that a core team be formed, who can be joined by specialist staff as necessary. It is suggested the core team comprise three or four control room operators, one or two field operators, two control room supervisors/managers and a safety advisor. Staff with specialist knowledge / responsibility for the following may need to be involved during the assessment:

- controlling operators working patterns - e.g. assigning operators to shifts, monitoring overtime, controlling shift swaps, ensuring minimum rest days etc.;
- fatigue / health monitoring;
- competency assessment;
- training and development; and,
- managing and writing operating procedures.

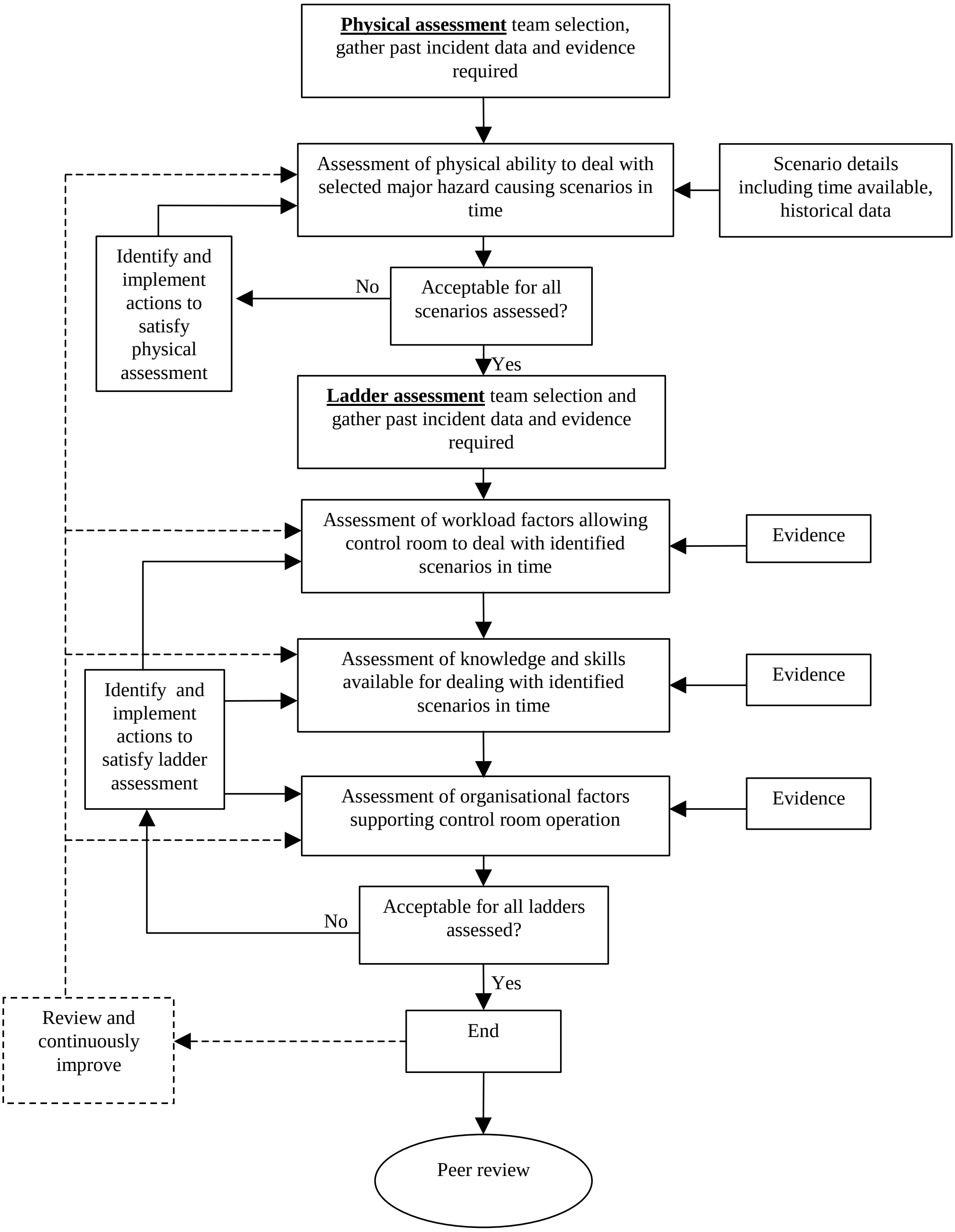
It is recommended that comments are sought from a majority, if not all, relevant operators before the assessment is finalised.

Are Human Factors skills needed?

In developing the method it has been the intention to avoid it being reliant on specialist skills that are not generally carried by sites. Given the nature of the subject, the key question is how much human factors knowledge is required.

In a standard HAZOP a technical / process perspective is taken, but the team should be mindful of human factors issues. For the staffing assessment the balance is reversed, with human factors being dominant. The use of structured analysis trees and descriptive anchors in the ladders is intended to reduce the need for Human Factors expertise. However, some Human Factors experience and understanding is required by the study facilitator to ensure that all human performance related issues are sufficiently understood and explored by the study team. Additionally, circumstances on a site may lead to doubt over the assessment or a certain task which is critical and the team may not be confident of their judgements. In such cases, recourse to a Human Factors specialist may become necessary.

Figure 7.1 Flowchart of the staffing assessment process



7.3 ASSESSMENT PROCEDURE

The procedure is summarised in Figure 7.1. The first stage is to test the staffing arrangements using the physical assessment trees. Once the arrangements pass this test, the second stage is to gauge them against the ladders.

7.3.1 Procedure for the physical assessment

Identify and define scenarios

Identify scenarios which could result in incidents with major hazard potential. There is no fixed rule on the number of scenarios that should or must be analysed - each plant or unit is different. Selection of scenarios is critical to the quality of the physical assessment and must include the worst case in terms of consequence and operator workload. The site's COMAH report, area HAZOP's or risk assessments plus incident reports can be used in scenario selection and the selected scenarios should be agreed amongst the assessment team prior to the study. It is recommended that scenarios representing the following are analysed:

- Worst case scenarios requiring implementation of the off-site emergency plan;
- Incidents which could escalate without intervention to contain the problem on site; and,
- Lesser incidents requiring action (representing a high workload) to prevent the process becoming unsafe.

Consider whether it is necessary to assess the scenarios at different times such as during the day and at night, during the week and at weekends, if staffing arrangements vary over these times.

Define the circumstances of each scenario in sufficient detail. As a minimum:

- Define who is controlling the process and their starting locations;
- Define who is available to support the incident, and their starting locations:
- Define the parameters that determine the time available to the operations team for detection, diagnosis and recovery. Therefore parameters such as process conditions, leak point, wind direction, release rate, time of day, may need to be defined.

Gather any historical data that is relevant to the detection, diagnosis and response to the selected scenarios.

Analysis session

Finalise the list of scenarios and their definition with the assessment team.

Select a scenario and before analysing it with the assessment trees, talk it through to make an initial estimate of the timeline of the scenario and to identify who is involved and what actions they would take.

The facilitator should then lead the team through the branches of the physical assessment trees.

In regard to completing the trees:

- Claims that main systems or back-up equipment *will not fail* should be evidenced by such means as showing all efforts which are reasonably practical have been taken (e.g. there is sufficient redundancy and back-up systems are invulnerable to common cause failures). Preventive maintenance routines and regular operation of backup equipment are also examples of measures to reduce failure rates. Such substantiation is required by the boxes *why?* or *why not?*

- Similarly, where it is asked whether it is feasible for an operator to deal with an alarm within the time available or whether it is feasible to diagnose and recover the problem in time, it is necessary for the human failure rate to be as low as reasonably practicable. Consideration should be give to what failure rate can be tolerated - is it 1 in 10,000, 1 in 100, 1 in 5? - before it is assessed whether reliability is sufficient. It is in making judgements on human reliability that a lack of human factors expertise will be felt. The facilitator should be aware of over confidence in regard to human reliability estimates (for example, a failure rate of 1 in 1000 or less represents exceptional performance on complex tasks).

- Successful recovery means that the process is in a safe state; and,

- When considering what else an operator might do, or what might distract them, consider all of the activities that an operator performs (see Table 7.1).

Key assumptions, judgements and concerns at each branch should be recorded.

On completion of each scenario, review the assessment and list the actions arising, giving each a unique number and assigning responsibility and completion dates. Actions are anticipated to be of the form:

- Further investigation required, such as determine reliability of equipment, check assumptions about the behaviour of the leaks;

- Identify improvements options, such as modifications to procedures; or,

- Consult with a Human Factors expert on key judgements.

Repeat the above for each scenario.

Table 7.1 Activities and tasks that could be undertaken by an Operator

Activity	Tasks
On-going control of the process to produce products	Control product quality
	Assist the maintenance of the process
	Assist in testing/ developing the process
	Start-up the process
Minimise consequences of releases	Detect releases
	Minimise the impact to onsite and offsite
	Liaise with incident response organisation
Enable maintenance and upgrading of the process control system	Provide access to the control system to enable maintenance
	Provide facilities to enable the control system to be upgraded
Generate information for accounting function	Generate daily accounting data
	Generate specific data (for ship loading)

7.3.2 Procedure for the ladder assessments

If weaknesses have been identified by the physical assessment, it is recommended solutions should either be scoped or implemented before the ladder assessments are completed.

Identify the core assessment team and the staff/managers with specialist knowledge to contribute to the assessment of particular ladders.

Two routes are open to completing the ladder assessments. One approach is for the facilitator to assemble the core team and go through each ladder in turn over the course of a few sessions, with specialist staff/managers joining when necessary. The second approach is for the facilitator to consult with each member individually, and then bring the team together for one session to present a draft analysis for discussion, refinement and agreement.

In either case, members of the team should work through the guidance questions that accompany each ladder. Support materials should be used as evidence whenever possible. Documents suggested as support material are listed in Table 7.2.

The rules for gauging where a plant/unit sits on the ladder is as follows:

- Start from the bottom rung and work upwards;
- If the arrangements fulfil the requirements defined in the rung, go on to the next rung;
- If the arrangements do not <u>fully</u> fulfil the requirements of the next rung, the plant/unit is rated as matching the rung below;
- The plant/unit cannot be rated above a rung that is partially fulfilled (i.e, even if the arrangements fulfil higher rungs, the rating sits below the lowest incomplete rung)

If the team concludes the arrangements fall below the acceptable line in a ladder, they should identify actions to raise them above the line as a first priority and actions to raise them towards demonstrated best practice as a second priority.

Finally, actions should be agreed, assigned and review and completion dates set.

7.4 CONTINUOUS IMPROVEMENT

Good practice will be to continuously seek ways of improving staffing arrangements, and thereby achieving or surpassing current best practice.

7.5 PEER REVIEW

As for other forms of safety assessment, peer review is recommended. It is a mechanism that can alert to bias, omission, optimism / conservatism in the assessment.

Given the nature of the subject, it is recommended that one or more reviewers with a mix of human factors, process and safety assessment experience be used.

Table 7.2 Suggested support material per ladder

Ladder	Support material
Situational awareness	Logbooks, incident reports which demonstrate action was taken later than it could have been, operating procedures, training and development programme
Teamworking	Operating procedures, definitions of roles and responsibilities, job descriptions for control room staff and support staff, training and development programme
Alertness and fatigue	Shift cycle and pattern (planned and actual which includes overtime and shift swaps), annualised hours sheets, examples of delayed reactions from historical incidents, absence records, evidence of health monitoring
Training and development	Training and development plans for control room staff and support staff, evidence of needs assessment, evidence of a structured skill step progression programme
Roles and responsibilities	Job descriptions for control room staff and support staff, structured assessment of core competencies required, skill step progression programme which shows evidence of core competencies
Willingness/Attitude	Cost data associated with recovery actions, training records, operating procedures
Management of operating procedures	Operating procedures showing date issued, author, approver, version number, quality manual detailing how procedures are managed, procedure audit results
Management of change	Procedures for managing change, equipment, procedures and organisational, organisational change policy document, evidence of review after implementing change, evidence of change (equipment and organisational) being risk assessed
Continuous improvement of safety	Site safety policy, safety statistics, incentive scheme details, graphs displayed on noticeboards, output from continuous improvement initiatives, company wide literature with safety information included (improvement ideas, incident reports etc)
Management of safety	Site safety policy, safety audit reports and action plans, performance monitoring graphs, evidence of safety management system, safety committee minutes, continuous improvement team output, company wide literature with safety information included (safety improvement initiatives and safety performance figures)

8. GUIDANCE ON ASSESSING CHANGES IN STAFFING ARRANGEMENTS

8.1 INTRODUCTION

Changes in staffing arrangements should be evaluated prior to implementation. Any change that could alter the rating from the method is considered to be a change in staffing arrangements.

A guiding principal is that changes should not lead to a reduction in the rating from the staffing assessment method.

8.2 PROCEDURE

A straightforward procedure is proposed:

- Produce an up-to-date baseline assessment of the existing arrangements;
- Define the proposed change, and evaluate it using the assessment method, modifying the plans until an equal or better rating is achieved;
- Re-assess the arrangements at a suitable time after implementation (within six months).

8.3 HOW CHANGES CAN IMPACT THE ASSESSMENT

The possible effects of some changes are summarised below (see Table 8.1):

Change in operations staff

This includes an increase or decrease in the number of operators continuously present in the control room and field, or a change in personnel (e.g. the transfer of operators from another section of the site who are unfamiliar or partially familiar with the process and how it is controlled). This type of change is likely to affect all the assessment elements except the management of change.

Change in technical shift support staff

As above this includes a change in number or a change in the individuals. Although they may not control the plant, since they form part of the shift team with operators any change in this group is likely to affect the same elements as a change in operations personnel.

Change in administrative staff or technical day support staff

As above this includes a change in number or a change in individuals. Although these are unlikely to be a prime source of assistance the availability of administrative or technical day support staff may affect the workload of operators during normal and/or upset conditions. Therefore any change in this group could affect the elements associated with workload plus knowledge and skills (as roles and responsibilities could change).

Change in shift system

A change in the shift system is likely to directly affect the physical ability and workload elements and impact on the time operators have available for training and development, project work, writing and reviewing procedures, being involved in continuous improvement initiatives and incident investigation. If a shift system requires operators to work a high level of overtime it is likely to curtail time being spent on other activities.

Change in process control hardware

Any change to hardware such as a DCS upgrade, an alarm management software upgrade or a new item of plant should require; re- assessment of staffing arrangements. The elements affected will be determined by the nature of the change. The physical assessments should be re-analysed, as should the workload elements of situational awareness, teamworking and alertness and fatigue. Additional elements may also require assessment depending on the scope and content of the change.

Change in training and development programme

A major change to the training and development programme for operators is likely to affect all elements except alertness and fatigue. Training and development underpins the ability of operators to deal with scenarios physically and in terms of situational awareness, teamworking and the knowledge and skills elements. A change in this area also impacts on organisational factors.

Change in operating procedures

As for a change in training and development, a change in operating procedures is likely to affect all elements except alertness and fatigue as it is very closely linked to the training and development function.

Senior management change

A senior management change is likely to affect how issues covering knowledge and skills and organisational factors are managed and could affect the performance of process operation staffing arrangements.

Table 8.1 Summary of elements affected by changes

Type of change	Physical ability	Situational awareness	Teamworking	Alertness & fatigue	Training & development	Roles & responsibilities	Willingness/attitude	Management of operating procedures	Management of change	Continuous Improvement of safety	Management of safety
Change in control room staff	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
Change in control room technical shift support staff	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
Change in control room admin shift support staff, technical day support staff or admin day support staff	✔	✔	✔		✔	✔					
Change in shift system	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
Change in process control hardware	✔	✔	✔	✔							
Change in training and development programme	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔
Change in operating procedures	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔
Senior management change					✔	✔	✔	✔	✔	✔	✔

9. FUTURE WORK

9.1 HAVE THE OBJECTIVES BEEN ACHIEVED?

From the experience and comments during the piloting and case studies, there are grounds for confidence. Staffing in the process industries is, undoubtedly, a complex issue and determining whether staffing arrangements are safe is a non-trivial task. It is hoped that the method allows organisations to make informed decisions about staffing arrangements, particularly when changing staffing numbers.

9.2 FUTURE DEVELOPMENT OF THE METHOD

The method described in this report is ready to be applied. Additional refinement through repeated practical application is anticipated and the ladders in particular could be further enhanced as greater application experience is gained.

The method's structure allows it to be added to (new ladders or assessment trees) or modified (e.g. revision of the ladders). It is anticipated that expansion or amendment will come as experience of applying the method is accumulated and 'best practice' evolves. The method may benefit from in being used in conjunction with task analysis or other specialised assessment tools.

Although the method has been developed primarily to assess staffing arrangements in control rooms, case study experience has demonstrated that often it is necessary to assess the entire shift operations team and the method easily lends itself to being applied in this way.

Research opportunities

The literature review shows there is a pool of relevant research on which to draw. It also shows a need to convert research methods into analytical tools that are suitable for wider adoption.

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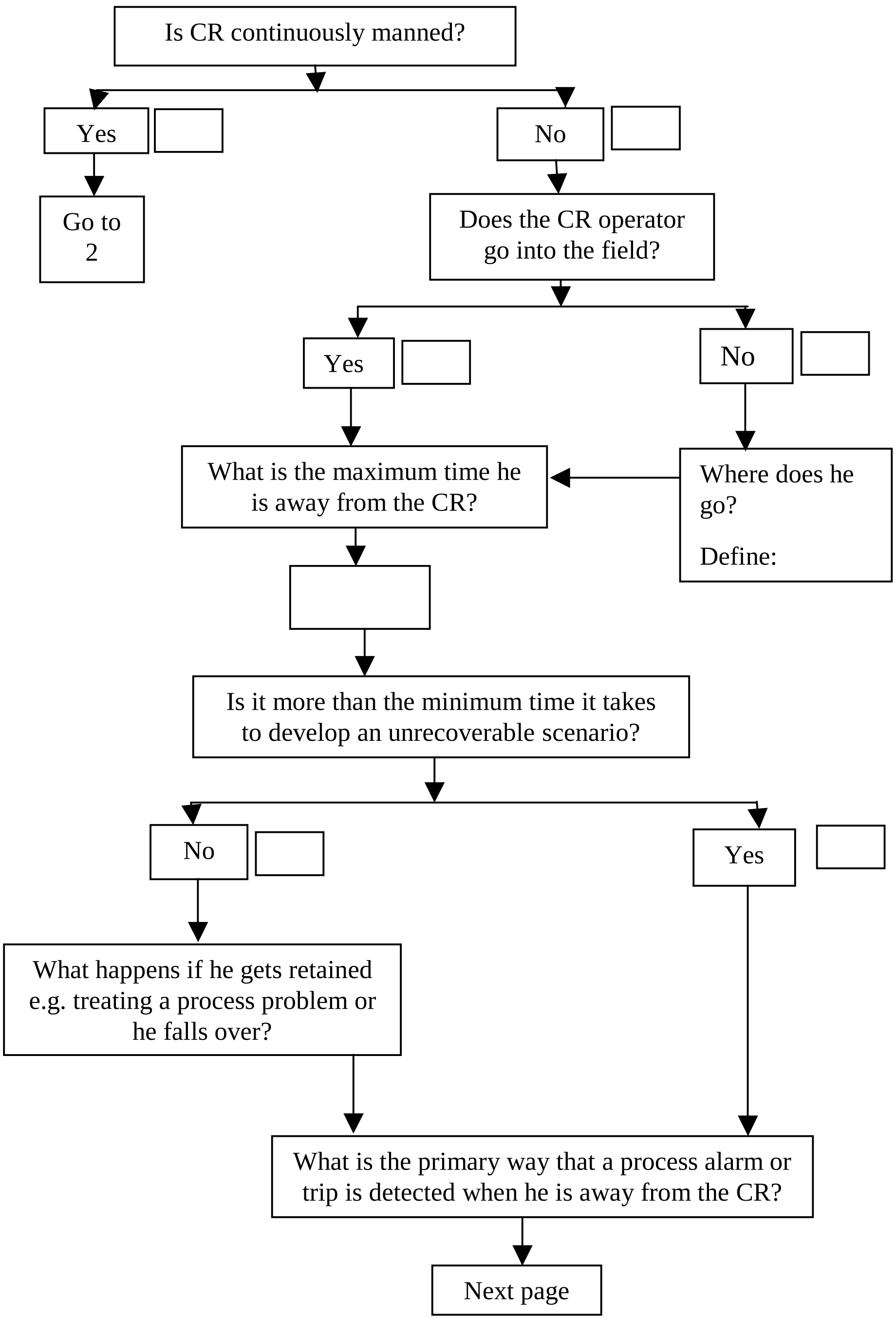
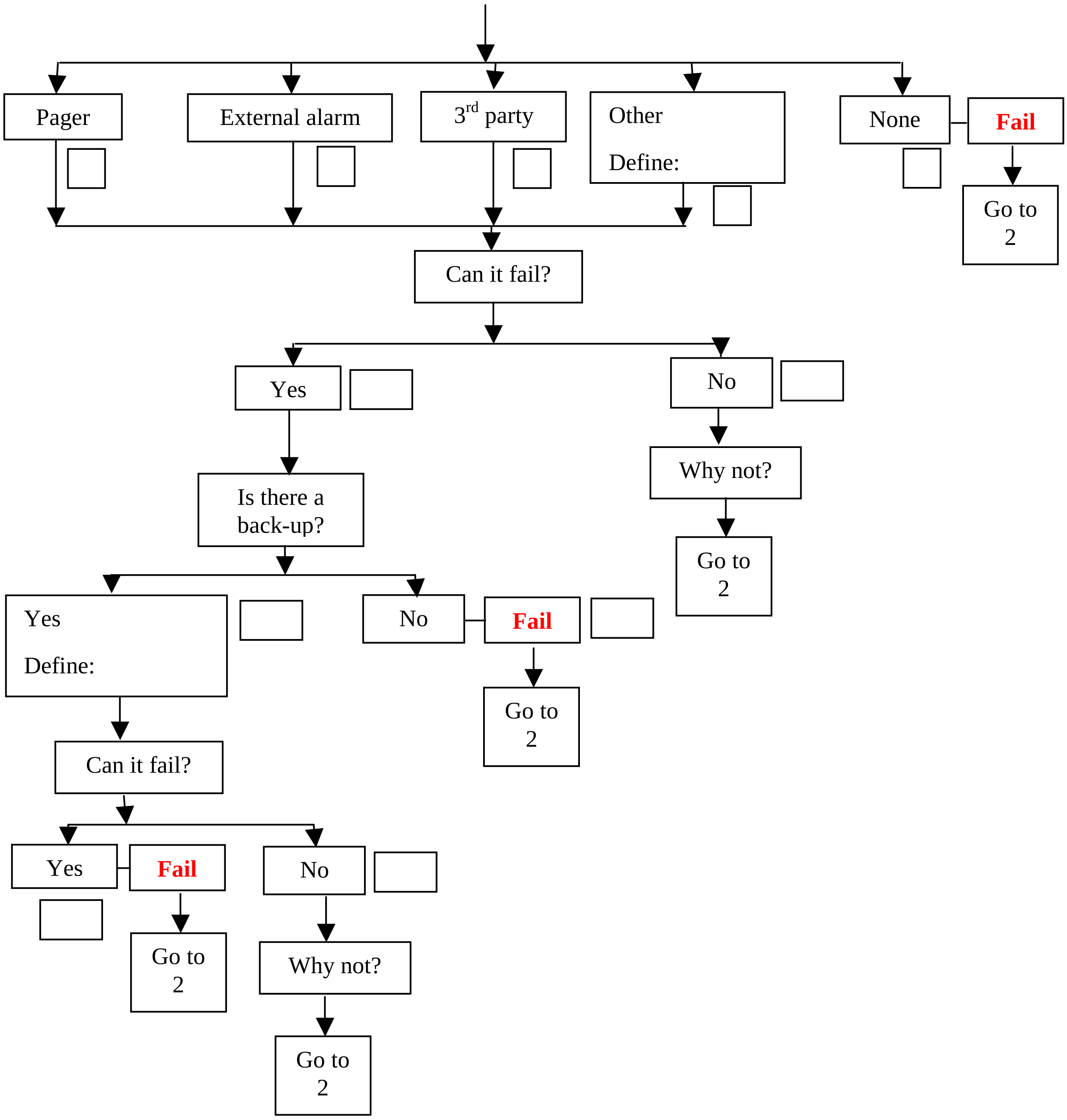
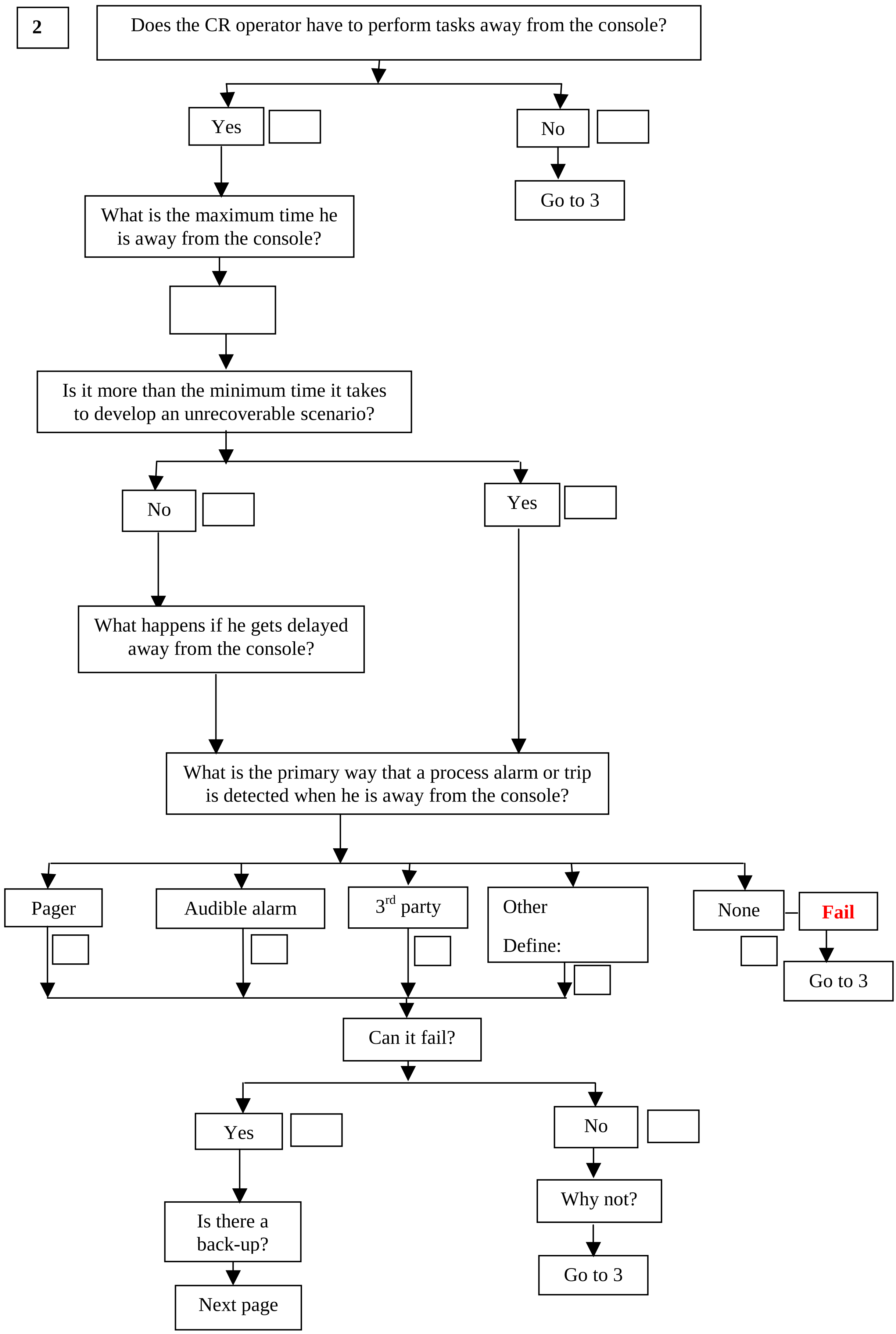
APPENDIX A

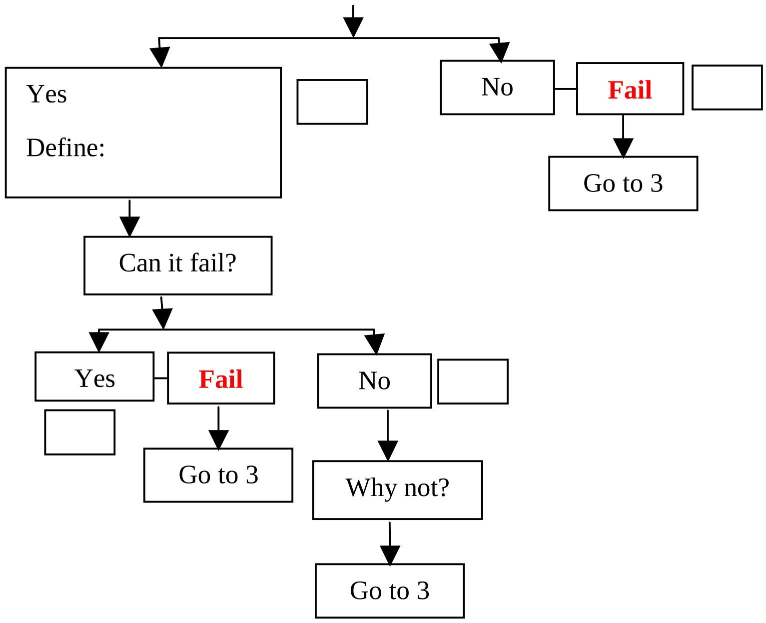
Physical assessment trees

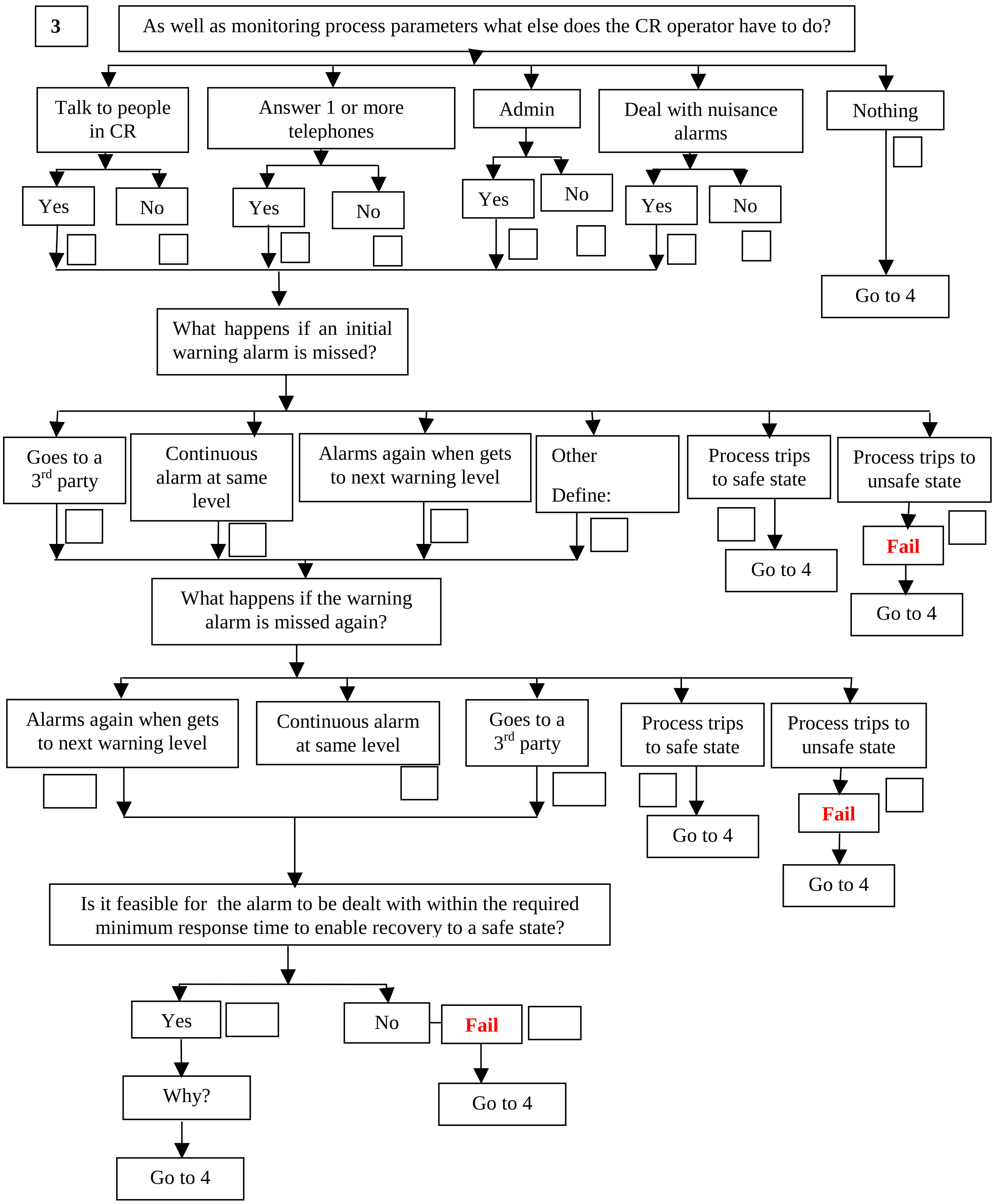
1

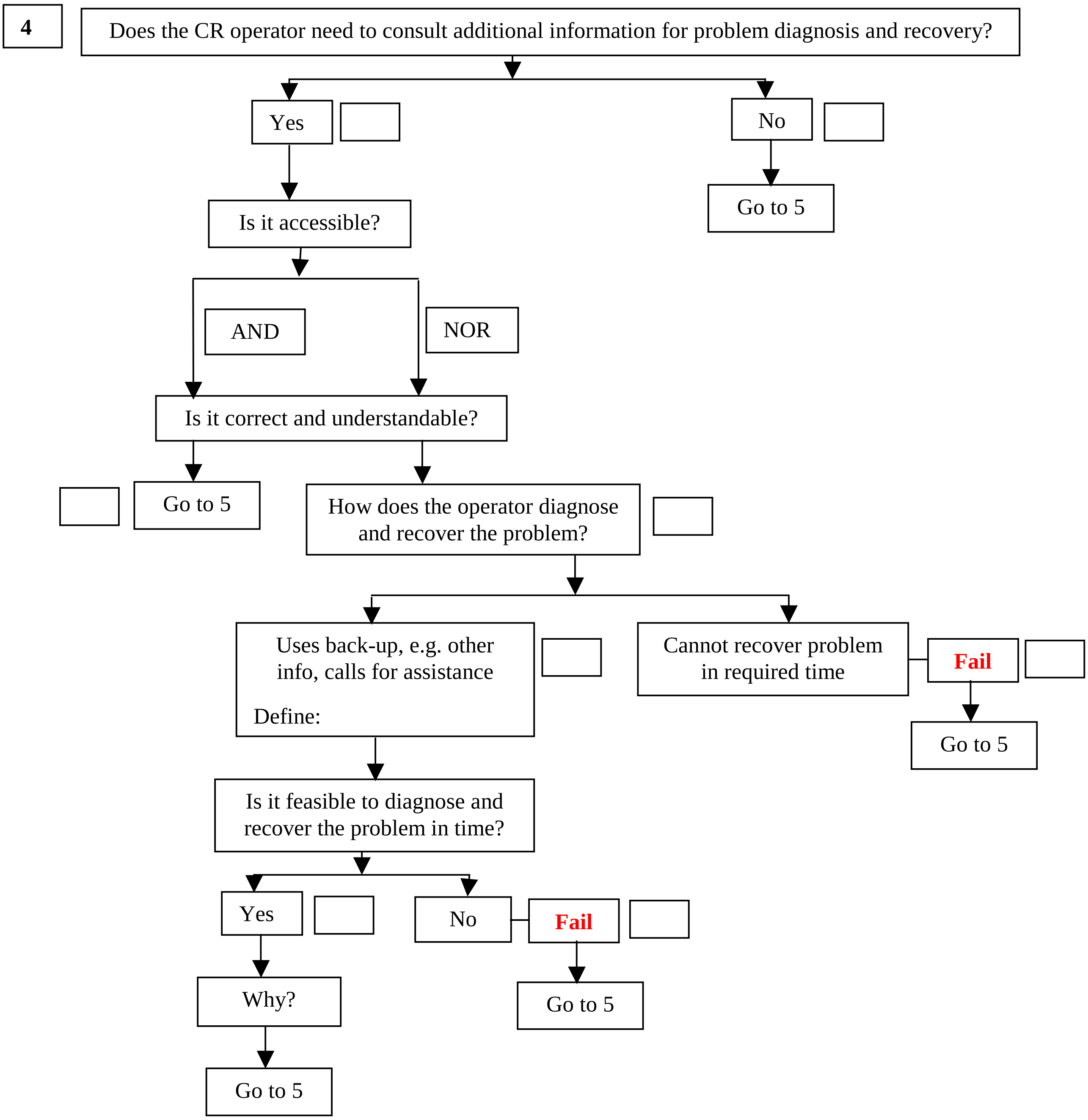

Is CR continuously manned?
Yes
No
Go to 2
Does the CR operator go into the field?
Yes
No
What is the maximum time he is away from the CR?
Where does he go?
Define:
Is it more than the minimum time it takes to develop an unrecoverable scenario?
No
Yes
What happens if he gets retained e.g. treating a process problem or he falls over?
What is the primary way that a process alarm or trip is detected when he is away from the CR?
Next page

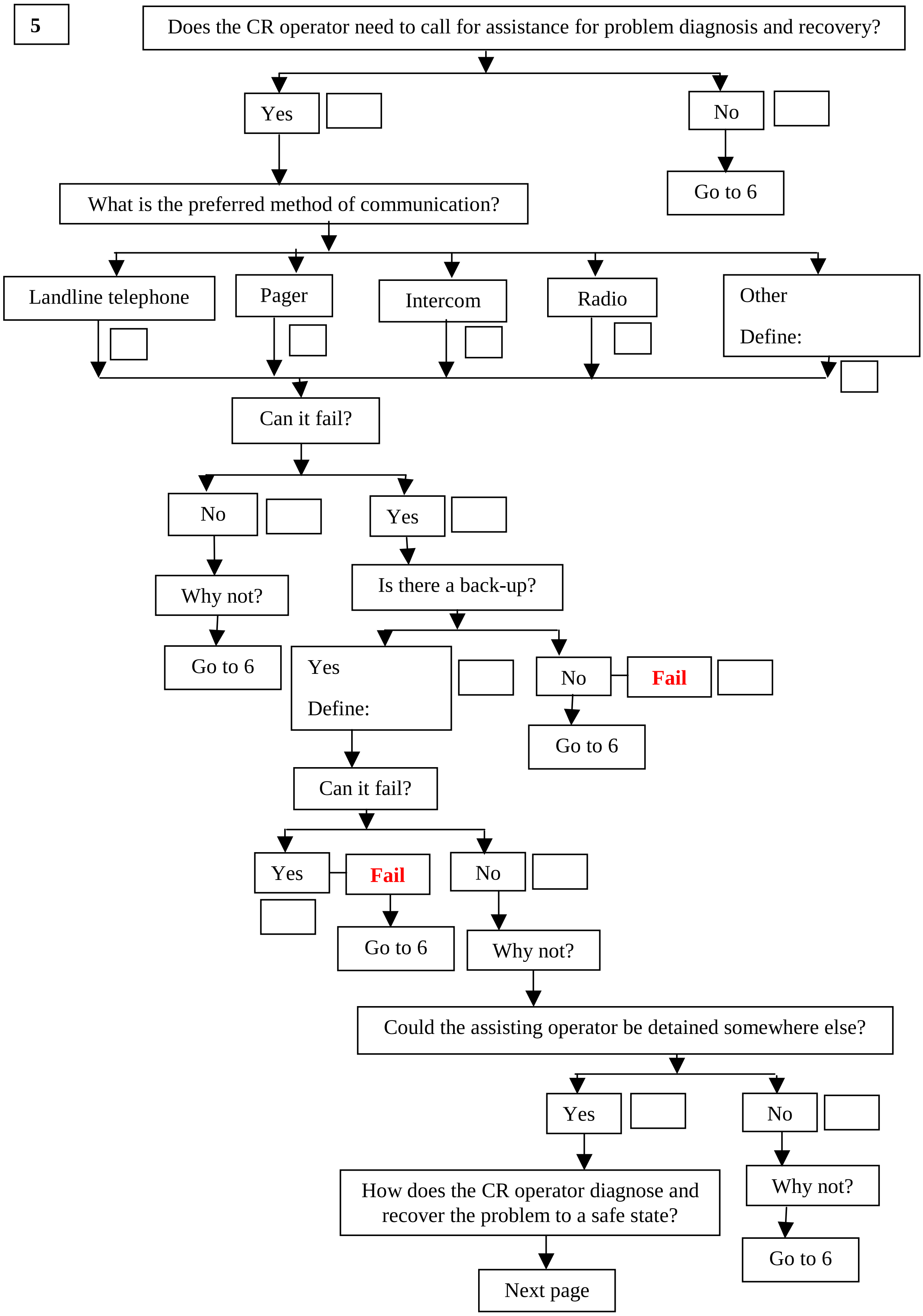

Pager
External alarm
3rd party
Other
Define:
None
Fail
Go to 2
Can it fail?
Yes
No
Why not?
Go to 2
Is there a back-up?
Yes
Define:
No
Fail
Go to 2
Can it fail?
Yes
Fail
Go to 2
No
Why not?
Go to 2

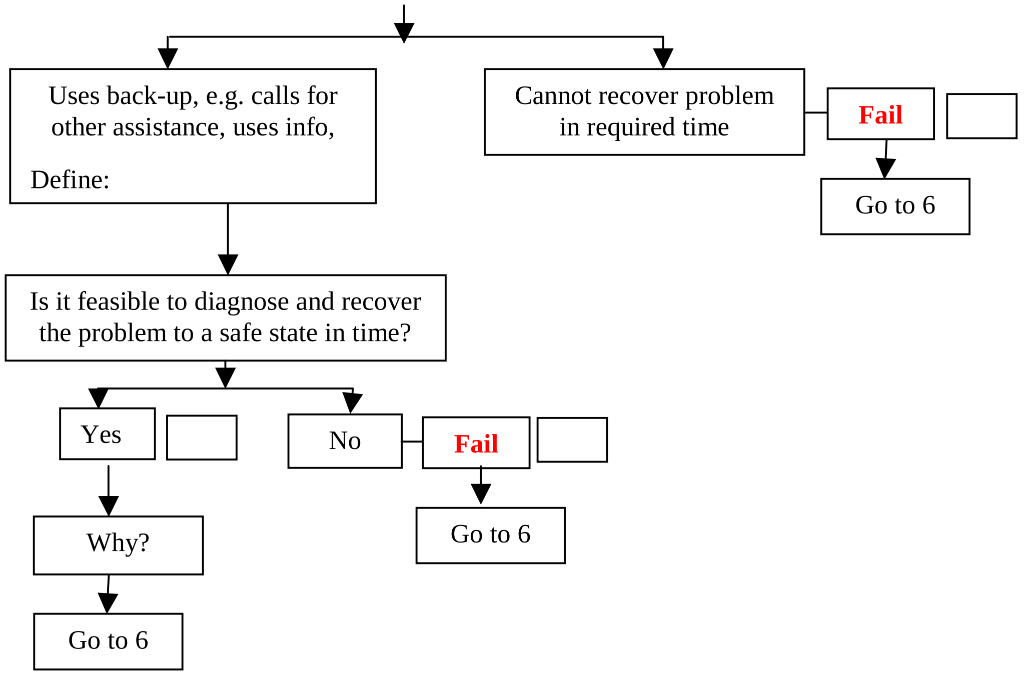

2
Does the CR operator have to perform tasks away from the console?
Yes
No
Go to 3
What is the maximum time he is away from the console?
Is it more than the minimum time it takes to develop an unrecoverable scenario?
No
Yes
What happens if he gets delayed away from the console?
What is the primary way that a process alarm or trip is detected when he is away from the console?
Pager
Audible alarm
3rd party
Other
Define:
None
Fail
Go to 3
Can it fail?
Yes
No
Is there a back-up?
Why not?
Next page
Go to 3

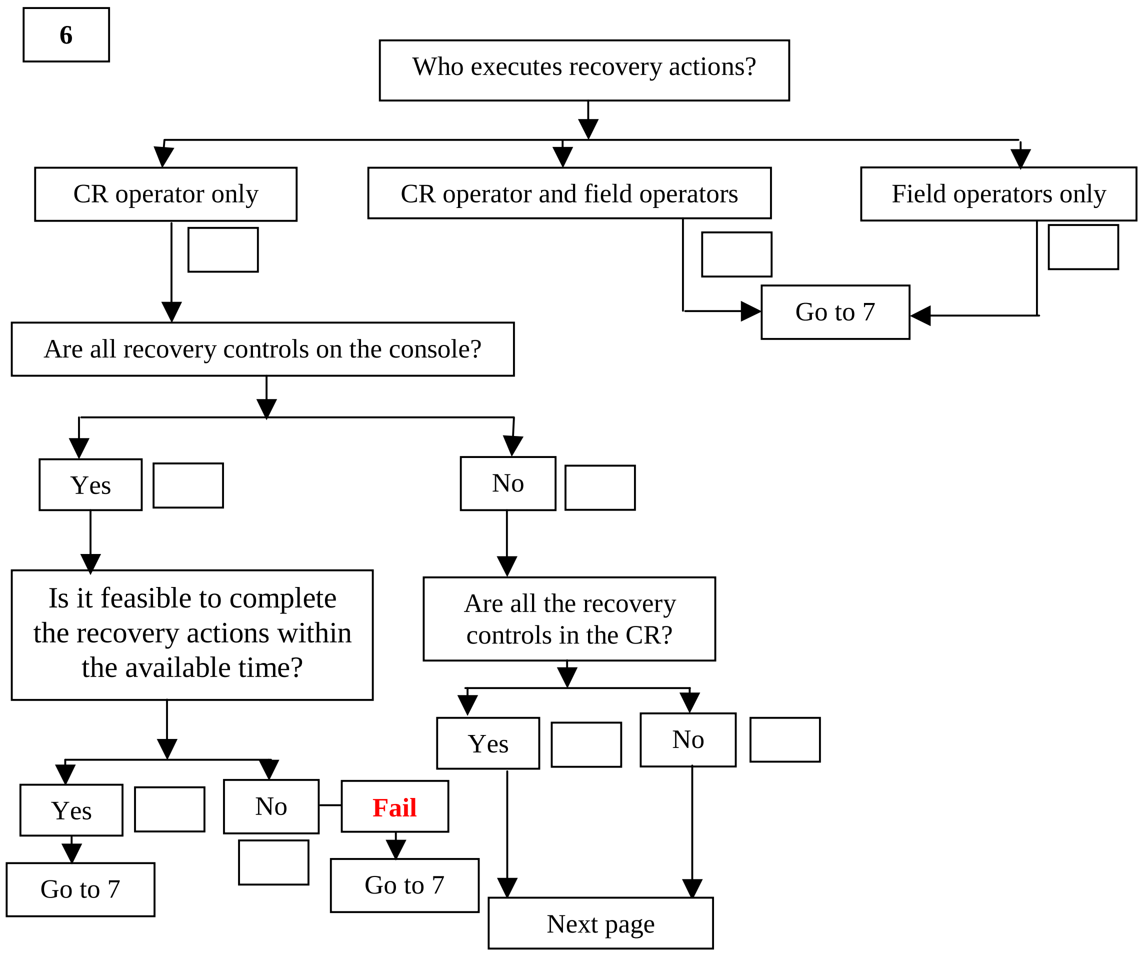

Yes
Define:
No
Fail
Go to 3
Can it fail?
Yes
Fail
No
Go to 3
Why not?
Go to 3

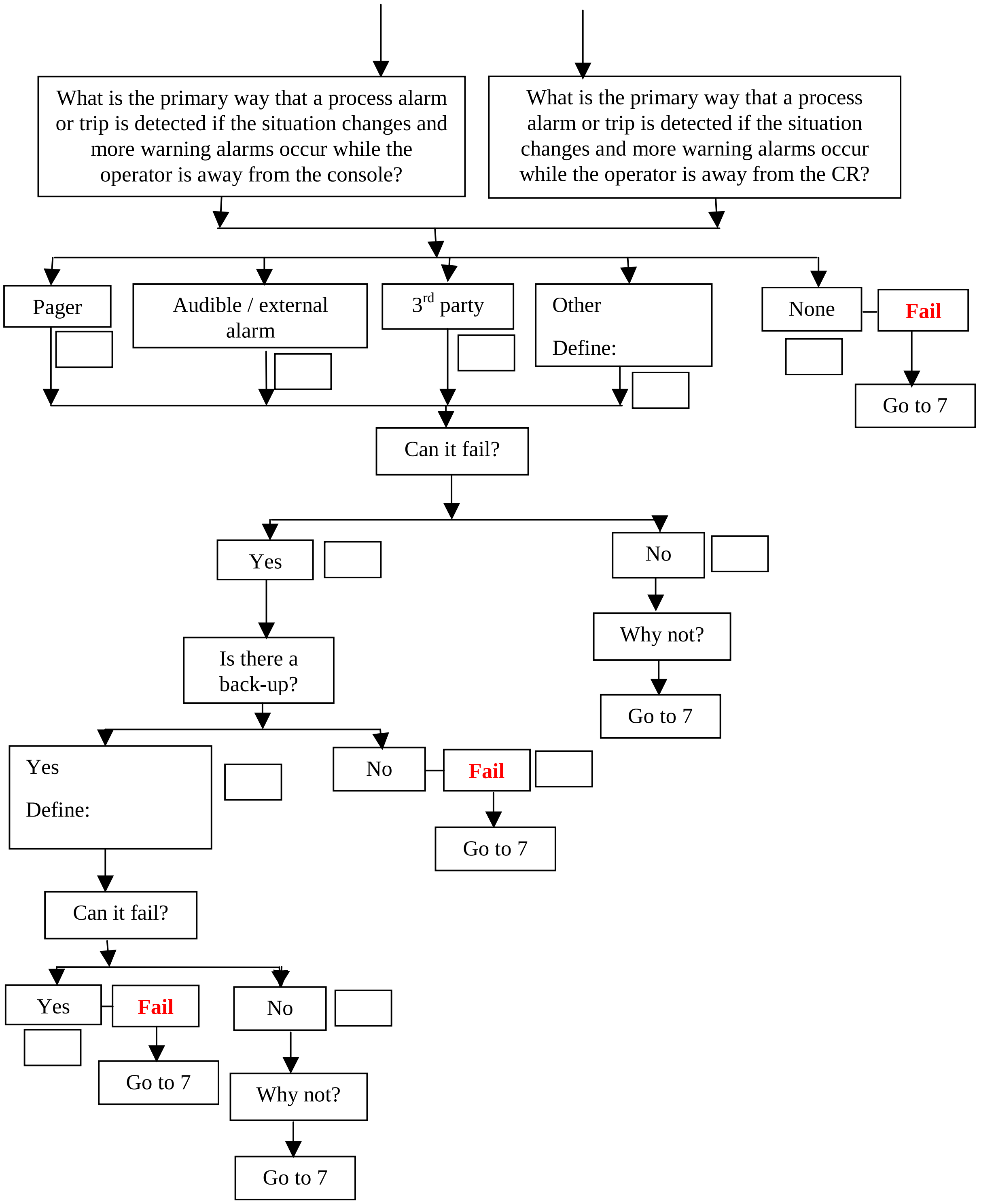

3
As well as monitoring process parameters what else does the CR operator have to do?
Talk to people in CR
Answer 1 or more telephones
Admin
Deal with nuisance alarms
Nothing
Yes
No
Yes
No
Yes
No
Yes
No
Go to 4
What happens if an initial warning alarm is missed?
Goes to a 3rd party
Continuous alarm at same level
Alarms again when gets to next warning level
Other
Define:
Process trips to safe state
Process trips to unsafe state
Go to 4
Fail
Go to 4
What happens if the warning alarm is missed again?
Alarms again when gets to next warning level
Continuous alarm at same level
Goes to a 3rd party
Process trips to safe state
Process trips to unsafe state
Go to 4
Fail
Go to 4
Is it feasible for the alarm to be dealt with within the required minimum response time to enable recovery to a safe state?
Yes
No
Fail
Why?
Go to 4
Go to 4

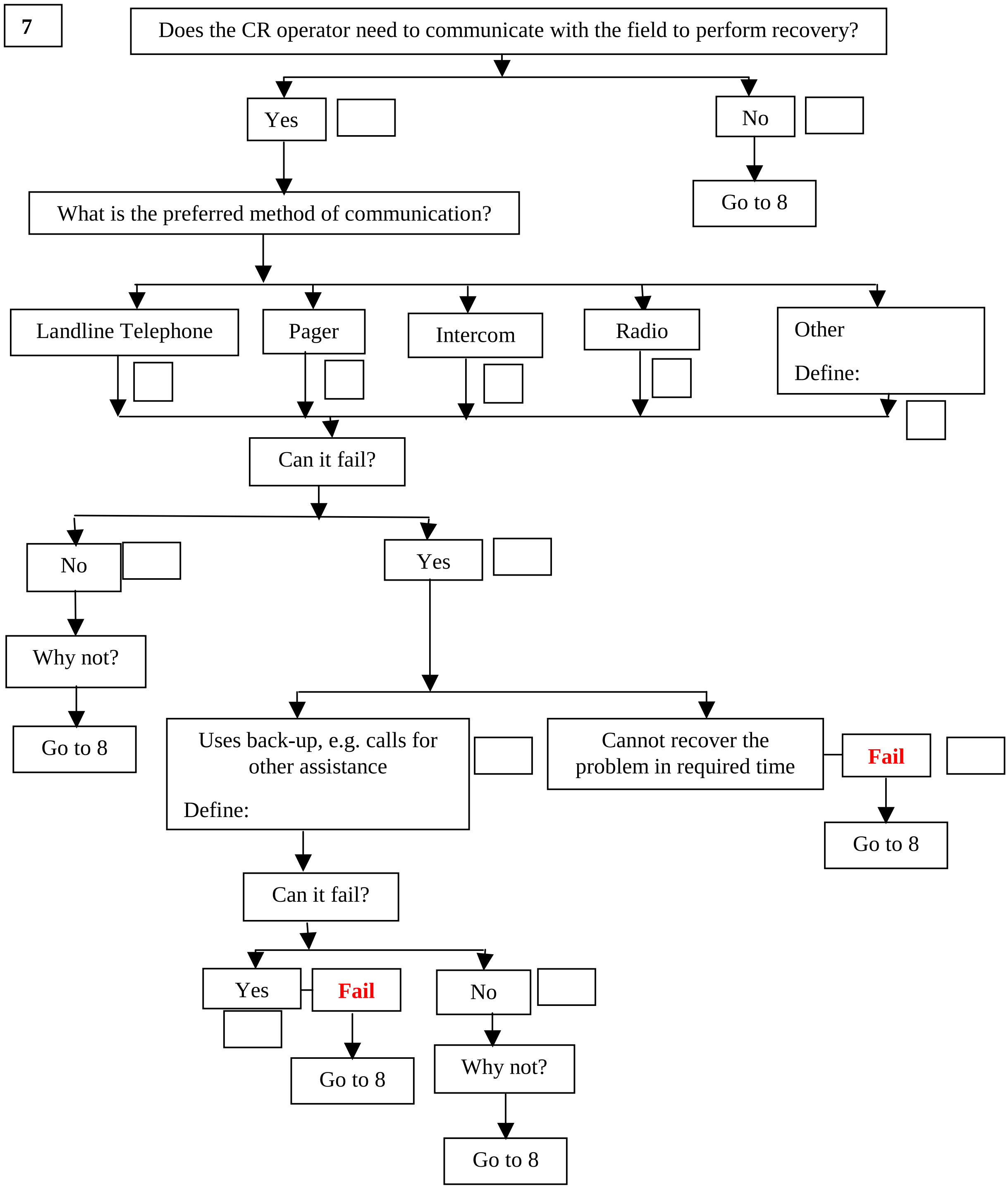

4
Does the CR operator need to consult additional information for problem diagnosis and recovery?
Yes
No
Go to 5
Is it accessible?
AND
NOR
Is it correct and understandable?
Go to 5
How does the operator diagnose and recover the problem?
Uses back-up, e.g. other info, calls for assistance
Define:
Cannot recover problem in required time
Fail
Go to 5
Is it feasible to diagnose and recover the problem in time?
Yes
No
Fail
Why?
Go to 5
Go to 5

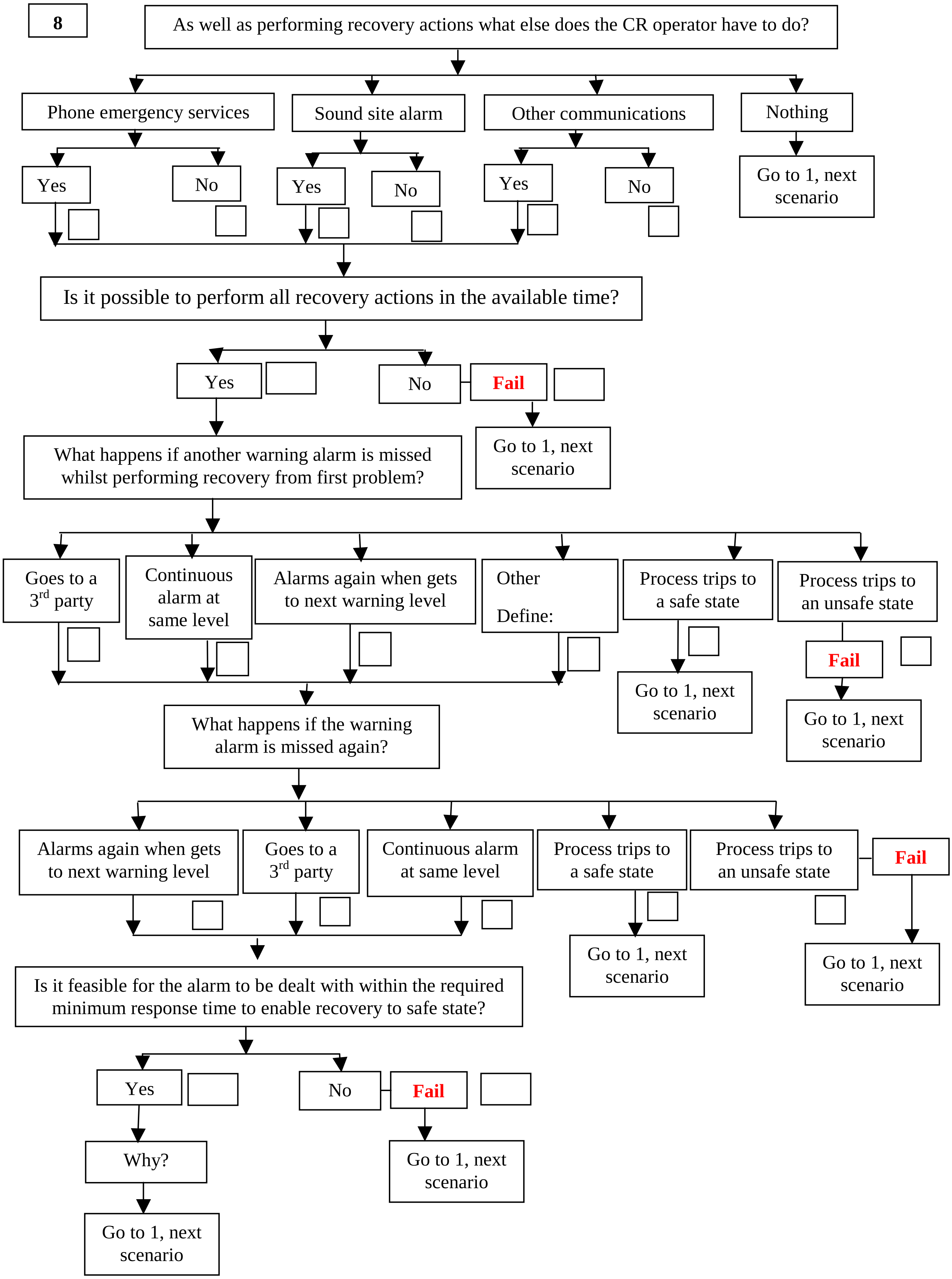

5
Does the CR operator need to call for assistance for problem diagnosis and recovery?
Yes
No
Go to 6
What is the preferred method of communication?
Landline telephone
Pager
Intercom
Radio
Other
Define:
Can it fail?
No
Yes
Why not?
Go to 6
Is there a back-up?
Yes
Define:
No
Fail
Go to 6
Can it fail?
Yes
Fail
No
Go to 6
Why not?
Could the assisting operator be detained somewhere else?
Yes
No
How does the CR operator diagnose and recover the problem to a safe state?
Why not?
Go to 6
Next page


Uses back-up, e.g. calls for other assistance, uses info,
Define:
Cannot recover problem in required time
Fail
Go to 6
Is it feasible to diagnose and recover the problem to a safe state in time?
Yes
No
Fail
Go to 6
Why?
Go to 6


6
Who executes recovery actions?
CR operator only
CR operator and field operators
Field operators only
Go to 7
Are all recovery controls on the console?
Yes
No
Is it feasible to complete the recovery actions within the available time?
Are all the recovery controls in the CR?
Yes
No
Yes
No
Fail
Go to 7
Go to 7
Next page


What is the primary way that a process alarm or trip is detected if the situation changes and more warning alarms occur while the operator is away from the console?
What is the primary way that a process alarm or trip is detected if the situation changes and more warning alarms occur while the operator is away from the CR?
Pager
Audible / external alarm
3rd party
Other
Define:
None
Fail
Go to 7
Can it fail?
Yes
No
Why not?
Go to 7
Is there a back-up?
Yes
Define:
No
Fail
Go to 7
Can it fail?
Yes
Fail
Go to 7
No
Why not?
Go to 7


7
Does the CR operator need to communicate with the field to perform recovery?
Yes
No
Go to 8
What is the preferred method of communication?
Landline Telephone
Pager
Intercom
Radio
Other
Define:
Can it fail?
No
Yes
Why not?
Go to 8
Uses back-up, e.g. calls for other assistance
Define:
Cannot recover the problem in required time
Fail
Go to 8
Can it fail?
Yes
Fail
No
Go to 8
Why not?
Go to 8


8
As well as performing recovery actions what else does the CR operator have to do?
Phone emergency services
Sound site alarm
Other communications
Nothing
Yes
No
Yes
No
Yes
No
Go to 1, next scenario
Is it possible to perform all recovery actions in the available time?
Yes
No
Fail
What happens if another warning alarm is missed whilst performing recovery from first problem?
Go to 1, next scenario
Goes to a 3rd party
Continuous alarm at same level
Alarms again when gets to next warning level
Other
Define:
Process trips to a safe state
Process trips to an unsafe state
Fail
Go to 1, next scenario
Go to 1, next scenario
What happens if the warning alarm is missed again?
Alarms again when gets to next warning level
Goes to a 3rd party
Continuous alarm at same level
Process trips to a safe state
Process trips to an unsafe state
Fail
Go to 1, next scenario
Go to 1, next scenario
Is it feasible for the alarm to be dealt with within the required minimum response time to enable recovery to safe state?
Yes
No
Fail
Why?
Go to 1, next scenario
Go to 1, next scenario

APPENDIX B

Ladder assessments (preparatory questions and ladders)

SITUATIONAL AWARENESS (WORKLOAD)

Introduction

To progress beyond the acceptable line on the ladder for situational awareness it is necessary to demonstrate that **operators** are able to gauge **accurately** and **reliably** within the **available time** the condition and behaviour of the plant in normal **and** in upset/emergency conditions, **without reliance on support.** Further explanation of the progression towards best practice is provided with the ladder.

Operators

1. Can you think of any examples of critical situations where you were uncertain about the state of the process, please provide details?
   a) Have you delayed actions in order to obtain information about the process? How long for, typically?
   b) Have you misdiagnosed a situation?
2. How do you monitor process trends, please explain?
3. How do you decide when to take action to improve a process condition (e.g. through initial process warning alarms, from tracking plant conditions etc)?
4. How do you track plant conditions during:
   a) a shift?
   b) a day?
   c) a week?
5. What do you do to make shift handover easier for the shift coming on to understand the plant condition?
6. How easy do you find it to access process monitoring information with regard to:
   a) Finding the correct screens?
   b) The presentation of the screens?
   c) The reliability of the screens?
7. How would you like to improve the screens (e.g. presentation, more trends, refresh rate, ability to adapt displays)
8. How frequently are you disturbed in the middle of tracking process conditions?
   a) By what?
9. Can you schedule activities so that you are able to concentrate on particular tasks until complete, please explain?
10. Can you block non critical radio/telephone communication if required, please explain?
11. Have there been critical situations when you have been uncertain of the location or activity of field operators, please explain?

Management

1. How are process conditions monitored?
2. Are there any guidelines as to what to monitor and how often, please describe?
3. How is a shift handover managed to maintain situational awareness?

Documents

1. Logbooks
2. Incident reports which demonstrate action was taken later than could have been
3. Operating procedures
4. Training and development programme

Ladder assessment

Grade	Description	Explanation of progression	Rationale supporting assessment
A	There is **high** level of **continuity** in the **Operator(s)** tasks during **critical process** events, i.e. **Operators** are **not** required to perform tasks that **significantly disrupt** their **concentration** on the **process**, and they **are able** to **delay / bring forward** other activities in order to **minimise distractions**.	There is sufficient flexibility in the Operator(s) role to allow them to prioritise actions and so they have the ability to improve the maintenance of their SA during critical process events.	
B	During **critical process** activities that demand the **Operator's** attention, they are **not disturbed unnecessarily** by **other activities** such as mustering, site alarms, telephone/ radio communications, permit raising, issuing of interlock keys, visitors etc..	There is a positive contribution to situational awareness in Operator job design by minimising non-process related tasks .	
C	In upset **and** emergency conditions all **relevant Operators** and **Supervisor** can gauge **accurately** and **reliably** the **condition** and **behaviour** of the plant within the **available time**, **without disturbing** each other or **blocking** each other's access to information.	There has been a positive contribution in the design of the information systems to ensure that all relevant people who need to maintain situational awareness (SA) about the condition of the plant under all conditions can do so and do not have to distract each other and so do not have a detrimental effect on each others SA.	
D	The **presentation** of **information** makes it straightforward for **Operators** to gauge **accurately** and **reliably** within the **available time** the **condition** and **behaviour** of the plant in normal **and** upset / emergency conditions, **without** reliance on **support**.	Situational awareness is good under normal and upset/emergency conditions and the design of the information systems allows Operators to detect, diagnose and recover plant problems in time without having to rely on others for support	
X	It is **possible** for **Operators** to keep track of the process during upset / emergency conditions if they **work hard** to gather all relevant information from control room displays / log books. There **can be times** when they **rely** on **other** operators/ field operators relaying **key information** to them.	It is possible to maintain situational awareness in upset/emergency conditions but the reliability is questionable because Operators do sometimes rely on others for key information and have to work hard to do it.	
Y	**Information** about the process and plant condition is **adequate** for Operators to be **confident** they can monitor **'smooth' running**	Operator situational awareness is OK when the plant is running smoothly (i.e. best case).	
Z	**Operator**s find it **difficult** to keep track of the process even **in smooth conditions**. This may be due to **insufficient information**, **unreliability** of sensors or displays, or they **cannot attend** to the process because of **other tasks** they are required to perform, or **distractions**.	Poor practice, staffing arrangements do not fulfil any of the rungs above.	

TEAMWORKING (WORKLOAD)

Introduction

To progress beyond the acceptable line on the ladder for teamworking it is necessary to demonstrate that **support staff** are available **within** the **production area being assessed** and their **role** is **defined** to **support** the **control room or** the **field** operators when required and is **part** of their **function**. The **priority setting** for **actions** which need **support** is done by a **clearly identified individual** who has this **responsibility** as part of their **role**. Further explanation of the progression towards best practice is provided with the ladder.

Operators

1. Are support staff available to the:
    a) control room (CR), who are they?
    b) field, who are they?
2. Where are they based? (e.g in CR, on site within production unit, different production unit)
3. When are they used? (e.g times of high activity for problem solving and recovery or for start-up)
4. What do they do? (e.g. answer phones, provide technical assistance, help to re-start the plant)
5. Have dry runs been used to check that the CR and the field can recover in time, what did they demonstrate?
6. Is it clear who is directing and controlling the operations team during:
    a) Normal operation, please give examples?
    b) Upset/emergency operation, please give examples?
7. Is the ability reviewed in the event of changes?

Support staff

1. What are your normal duties when you are not required in the CR/field?
2. Is your role defined to support the CR/field as part of your function?
3. What do you do when you are required to support the CR/field?

Management

1. Are the roles and responsibilities of support staff defined?
2. Who directs and controls the operations team during:
    a) Normal operation, please give examples?
    b) Upset/emergency operation, please give examples?
3. Does training and dry runs take place to ensure that the CR and the field can recover in time from major hazard scenarios?
4. Is the ability reviewed in the event of changes?

Documents

1. Operating procedures
2. Definition of roles and responsibilities
3. Job descriptions for CR staff, field staff and support staff
4. Training and development programme

Ladder assessment

Grade	Description	Explanation of progression	Rationale supporting assessment
A	**Any changes** to process, procedures or staff initiate a **review** of the **operations shift team's ability** to **recover** the plant to a **safe state** within the **available time**.	The need for review of the ability to recover in time prior to any change is recognised and is triggered by the management of change process (organisational, procedural or process).	
B	It has **been proven** by **past incidents/dry runs** that the **operations shift team can recover** the plant to a **safe state** within the **available time**. **Support staff** may be **required** for **re-start up** and are on-call for this.	The operations team's ability to recover the plant to a safe state has been demonstrated and if support staff are on-call then it is for re-start-up only.	
C	The **operations team** is **multi-skilled** in **mechanical, electrical** and **instrumentation** aspects of the plant as well as **control room** and **outside pla**nt operation	The operations team is capable of dealing with equipment failure on shift and is capable of recovering the plant to a safe state in time in scenarios with equipment failure.	
D	The **operations team** is **multi-skilled** in **control room** and **outside plant operation**.	There is sufficient knowledge and understanding in all operators as to how the control system and the outside plant work so that there is an appreciation of the tasks which other team members carry out.	
E	**Shift support** staff for the **CR** are available **whenever required** and may perform either **admin/communication** tasks **or** provide **extra technical assistance**. Their support role is **defined** and **part of their function**. It is always **clea**r who is **directing activities** and **setting priorities**.	The CR has support staff available when required who perform either admin or provide extra technical assistance. This may be covered by the support staff in F who are also capable of assisting field operators or may be an additional resource (e.g. purely admin assistance)..	
F	**Shift support staff** are available **within** the **production area being assessed** and their **role** is **defined** to **support** the **control room or** the **field** operators when required and is **part** of their **function**. The **priority setting** for **actions** which need **support** is done by a **clearly identified individual** who has this **responsibility** as part of their **role**	Support staff are available when required and they assist where the person responsible for priority setting decides they are needed for a particular situation. Roles and responsibilities of support staff and he priority setter are defined as being part of their function. The availability of support is reliable and their actions are prioritised depending on plant conditions.	
X	**Shift support staff** are available on **different** areas of the site and are **only** available **if** that process can **spare** them.	Support staff can only give support as a lower priority to their own productions area so their availability is not sufficiently reliable.	
Y	**Support staff** are available **on call-out** for **recovery**. It is **assumed** that they will arrive **in time**.	There is no on site support for the shift operations team. There is no evidence that recovery can be reliably achieved in time using on call staff.	
Z	There are **no support staff** available. It is **assumed** that the operations shift team **will cope** with all scenarios.	Poor practice, staffing arrangements do not fulfil any of the rungs above. It is simply assumed without any evidence, that the operations team will cope with all scenarios.	

ALERTNESS AND FATIGUE (WORKLOAD)

Introduction

To progress beyond the acceptable line on the ladder for work pattern alertness and fatigue it is necessary to demonstrate that there is a **limit** on the amount of **overtime** operators can work and **individual operator's overtime** is **monitored** to **ensure** the **limit** is **not exceeded**. To progress beyond the acceptable line on the ladder for health alertness and fatigue it is necessary to demonstrate that a **health monitoring programme** is used to **monitor** for **signs of long term fatigue** and **chronic stress**. Further explanation of the progression towards best practice is provided with each ladder.

Operators

1. Do you sometimes feel sleepy when operating the CR?
    a) When?
    b) How frequently?
    c) What do you think causes it? (e.g. boring tasks, poor lighting, temperature, humidity, long shifts, mornings/afternoons/nights)
    d) What do you do to try to combat it?
2. Do you sometimes miss alarms, please give examples of where this has happened?
3. Does it take you longer to recognise and respond to plant conditions on certain shifts, please give examples of were this has happened?
4. Do you swap shifts?
    a) How often (e.g. how many times in a month)?
5. Do you work overtime?
    a) How often (e.g. how many times in a month)?

Management

(Work pattern)

1. Is consideration given to passive versus active tasks in job design?
2. How have lighting and temperature levels been determined?
3. How was the shift cycle and length determined (i.e. what were the identified requirements)?
4. Is there job rotation during shifts, please explain?
5. Is there job rotation during the shift cycle, please explain
6. Are there restrictions on operators swapping shifts, please explain?
7. Are there maximum working hours criteria, please explain?
8. Are there minimum rest days criteria, please explain?
9. Are there controls on the amount of overtime?

a) During normal operation, please explain?

b) During high workload periods such as start-up/shutdown, please explain?

(Health)

10. Do you monitor the causes of absence, please explain?
11. Do you monitor for signs of fatigue through absence or health monitoring, please explain?
12. Do you monitor for signs of chronic stress through absence or health monitoring, please explain?
13. Do you require operators to report particular types of medication?

Documents

1. Shift cycle and pattern
2. Examples of delayed reactions from historical incidents
3. Absence records
4. Evidence of health monitoring programme

Ladder assessment (work pattern)

Grade	Description	Explanation of progression	Rationale supporting assessment
A	The **controls** on **working pattern** (for all operators and individual operators) are **reviewed** in light of **experience**.	Shows a learning organisation which learns and improves through experience.	
B	Operators are a**ble to report concerns** they have **about fatigue / drowsiness** of **themselves** or **others**	The culture allows concerns to be reported as despite controls in place, operators may still experience fatigue and reporting allows the hazard to be minimised.	
C	It is **recognised** that operators may require **additional rest** days after periods of **exceptional workload**. **Flexibility** is built into the **rostering system** to enable this to occur.	The system has flexibility to allow extra recovery time when required.	
D	The amount **of time operators** are **alone** in the control room **during early morning** (0200 to 0600) is **minimised**. If it is common for operators to be alone at this time, **steps** are **taken** to **reduce the hazar**d of **operator drowsiness**.	Early morning hours are known to be a difficult time for alertness, this has been recognised by management and controls put in place to minimise this hazard.	
E	There is a **limit** on the amount of **overtime** operators can work and **individual operator's overtime** is **monitored** to **ensure** the **limit** is **not exceeded**.	Overtime is limited and actively monitored to ensure the control works in practice.	
W	The **exchanging of shifts** between operators is **recorded and periodically reviewed**.	The actual working pattern of operators is actively managed through recording and review.	
X	The **ergonomics** of the control room environment **mitigate tiredness** (lighting, temperature, humidity)	There are controls in place to aid alertness during a shift.	
Y	**Limits** are placed on operator's **working pattern**, such as: **maximum** shift length**, maximum** number of shifts in a sequence, **minimum** rest time between shifts**, minimum** rest days per week/month.	There are clear controls on operator working patterns.	
Z	Operators are **allowed** to work **excessive hours without sufficient rest**. This includes **double shifts** and **number of days in a row**.	Poor practice, staffing arrangements do not fulfil any of the rungs above. There are no controls on work pattern to prevent a reduction in alertness or an increase in fatigue.	

Ladder assessment (health)

Grade	Description	Explanation of progression	Rationale supporting assessment
A	The **controls** on **medication** (for all operators and individual operators) are **reviewed** in light of **experience** (including health monitoring)	Shows a learning organisation which learns and improves through experience.	
B	A **health monitoring programme** is used to **monitor** for **signs of long term fatigue** and **chronic stress**.	There is a monitoring control in place to check that all management controls on working pattern and alcohol, drugs and medication are working and enable any negative impact of factors external to work to be identified.	
Y	There are **clear instructions** on the types of **medication** operators must **notify management** about	There is a management control in place.	
Z	There are **no controls** on alcohol, drugs etc.	Poor practice, staffing arrangements do not fulfil any of the rungs above. There are no controls on alcohol, drugs etc. which could reduce alertness or increase fatigue.	

TRAINING AND DEVELOPMENT (KNOWLEDGE AND SKILLS)

Introduction

To progress beyond the acceptable line on the ladder for training and development it is necessary to demonstrate that **each operator** has **a training and development plan** to progress through **structured, assessed skill steps** combining **work experience** and **paper based** learning and training sessions. **Training needs** are **identified** and **reviewed regularly** and **actions** taken to **fulfil needs**. Further explanation of the progression towards best practice is provided with each ladder.

Operators and covering operators

1. Have you got a training and development plan, what does it include?
2. What form did your initial training and assessment take?
3. Do you get regular refresher training?

a) What form does it take?

b) How are you assessed?

4. What kind of training do you get on major hazard scenarios?

a) How often?

b) How are you assessed?

5. Do you get training on new procedures, new equipment or if your job changes, please provide examples?

Management

1. Who is responsible for CR and field staff training?
2. How is the operations team training and development plan structured?
3. Are there progressive skill levels for operators to work through, please explain?
4. When and how is training given on process, procedure or job changes?

Documents

1. Training and development plans for control room staff and support staff
2. Evidence of training needs assessment
3. Evidence of a structure skill step progression programme

Ladder assessment

Grade	Description	Explanation of progression	Rationale supporting assessment
A	**Process/procedure/staffing changes** are **assessed** for **the required changes** to operator **training and development** programmes. **Training** and **assessment** is provided and the **success** of the **change** is **reviewed** after implementation.	The training and development system is dynamic and integrated into the management of change process.	
B	**All operators receive simulator or desktop exercise training** and **assessment** on **major hazard scenarios** on a **regular basis** as part of a **structured** training and development **programme**.	Operators get a regular opportunity to practice major hazard scenarios through physical walk through's or simulators or by desk-top talk throughs.	
C	There is **a minimum requirement** for a **'covering' operator** based on **time per month** spent as a **CR operator** to ensure **sufficient familiarity**. Their **training and development** programmes **incorporate** this requirement.	It has been recognised that anyone covering the control room must be competent and their skills kept up to date.	
D	**Each operator** has **a training and development plan** to progress through **structured, assessed skill steps** combining **work experience** and **paper based** learning and training sessions. **Training needs** are **identified** and **reviewed regularly** and **actions** taken to **fulfil needs**.	The training and development needs are identified, provided and reviewed on an individual basis allowing operators to improve and extend their skills and understanding. It provides operators with a motivation to improve and continue to develop.	
W	**All operators** receive refresher training and assessment on **major hazard scenario** procedures on a **regular, formal** basis.	The need for formalised regular refresher training for major hazard scenarios has been recognised as essential when they are such infrequent events with severe consequences.	
X	**New operators** receive **full, formal induction training** followed by **assessment** on the process during **normal operation** and **major hazard** scenarios	Full training and assessment for new operators, it is formalised and covers normal operation plus major hazard scenarios.	
Y	There is an **initial** run through of **major hazard** scenario procedures by **peers**.	Only an informal briefing on major hazard procedures is provided to new operators.	
Z	There is **no evidence** of a **structured** training and development programme for operators. Initial training is **informally** by peers.	Poor practice, staffing arrangements do not fulfil any of the rungs above.	

ROLES AND RESPONSIBILITIES (KNOWLEDGE AND SKILLS)

Introduction

To progress beyond the acceptable line on the ladder for roles and responsibilities it is necessary to demonstrate that there is **a management control** in place to ensure that **core competencies** required for the operations team are **retained** during any **staffing changes**. Further explanation of the progression towards best practice is provided with each ladder.

Operators and covering operators

1. Have you got a job description?
2. Does it reflect what you do?
3. Has it changed, is it reviewed regularly?
4. Do you know what your tasks and responsibilities are in:
    a) Normal operation, please describe?
    b) Emergency situations, please describe?
5. How were these communicated to you?
6. Have they changed and how?
    a) Are you assessed against them regularly?
    b) How are you assessed?
7. Is your training and development linked to your role and responsibilities, please explain how?

Management

1. How was the shift team composition determined, what method was used? (e.g. activity analysis, identification of core competencies)
2. What are the core competencies required within the CR and the field?
3. Do you reassess the core competencies required prior to changes in equipment/procedure/staff to ensure that they are retained or introduced?
4. Are core competencies used in the selection and training and development of operators?

Documents

1. Job descriptions for control room staff and support staff
2. Structured assessment of core competencies required
3. Skill step progression programme which shows evidence of core competencies

Ladder assessment

Grade	Description	Explanation of progression	Rationale supporting assessment
A	**Prior** to any proposed **change** to **equipment** or **procedures** the **core competencies** required for the operations team are **reviewed** and any **new core competencies** required after the change are **introduced**.	The management of change process considers core competencies affected or required for a proposed equipment or procedure change.	
B	The **operations teams** are **selected** and then **trained** on the basis of the **core competencies** identified. **Operator development** is **assessed** against these **criteria**.	Core competencies are consistently used throughout operator selection and development.	
C	There is **a management control** in place to ensure that **core competencies** required for the operations team are **retained** during any **staffing changes**.	The management control ensures core competencies are considered and retained through the management of change process for a staffing change to the operations team.	
V	**Additional roles** such as **First Aider, Search and Rescue** team member are **taken into account** when **assessing** the operations team's **ability** to cope with **normal** and **emergency** situations	The priority of each role an individual may have is clearly defined and understood by operators and management for normal and emergency situations and used in assessing the operations team ability to cope.	
W	**Roles** and **responsibilities** within the operations team are **clearly defined** so that **each individua**l knows their **allocated tasks** and **responsibilities** in **normal** and **emergency** situations.	Roles and responsibilities have been defined for individual and been detailed in terms of tasks and responsibilities for normal and abnormal operation.	
X	A **structured approach** has been used to **identify** the required **team competencies**.	The basis for required competencies can be demonstrated.	
Y	There is a **general job description** for each member of the operations team.	Roles and responsibilities are defined in a general way, not specific to an individual and not in detail.	
Z	There is **no definition** of team roles and responsibilities. There is **no identification** of core competencies.	Poor practice, staffing arrangements do not fulfil any of the rungs above.	

WILLINGNESS TO INITIATE MAJOR HAZARD RECOVERY (KNOWLEDGE AND SKILLS)

Introduction

To progress beyond the acceptable line on the ladder for willingness to initiate major hazard recovery actions it is necessary to demonstrate that operators are **not fearful** of **reprimand** if they **wrongly initiate 'costly' recovery** actions as long as they felt **justified** to do so. .Further explanation of the progression towards best practice is provided with each ladder.

Operators

1. Do you have a feel for the costs associated with emergency action?
2. What are they in terms of downtime/£'s/start-up requirements
3. How have you acquired this knowledge? (e.g. peers, briefings)
4. Are you cautious about taking particular actions because of costs or because you are worried about criticism?
5. Do you think that the written procedures correctly reflect the cost of recovery actions or take them into account, please provide examples?
6. Do you think that your understanding of associated costs is the same as other operators, supervisors, senior management?
    a) Have their perceptions been communicated to you? How?
    b) Have you been able to test their perceptions, please provide examples?
    c) Were there any discrepancies in practice, please provide examples?
7. Do you have environmental procedures which contradict certain recovery actions, please provide examples?
8. Is it clear to you when the plant is safe or unsafe and recovery actions are required?
    a) How?
    b) Do you think it is the same for experienced and inexperienced operators, please provide examples?
9. Could experienced operators disagree with inexperienced operators, please explain?
10. Are you worried about being too cautious if you initiate recovery actions, please explain?
11. Do you feel the need to ring somebody senior to yourself before initiating recovery actions?
    a) Do you have to?
    b) Do you feel more comfortable doing so?

Management

1. Have you assessed the costs associated with recovery actions? (e.g. equipment, lost product, start-up resources)
2. Have you communicated this to operators?

3. Are these taken into account when writing procedures?

4. Are procedures checked to ensure there is no contradiction with recovery actions required in the event of a major hazard scenario?

5. How is the relative importance of safety compared to productivity/environmental performance communicated? How often does this happen?

Documents

1. Costs associated with recovery actions

2. Training records

3. Operating procedures

Ladder assessment

Grade	Description	Explanation of progression	Rationale supporting assessment
A	The **management** is **fully aware** that **recovery** actions can be **'costly'** and **recognises** that **operators** may be **reluctant** to **enact recovery** because of the '**costs'**. They give **operators** regular opportunities to **test** their **willingness** to **initiate recovery** actions in **structured simulation** or **desk-top exercises**.	Practising scenarios and the associated decision making should improve the promptness of operator decision making and give them confidence about what the correct course of action is for a particular scenario.	
B	**If recovery** actions can be '**costly'**, the **organisation** is **proactive** in finding ways of **reducing** the '**costs'**, with **operators** being closely **involved** in these efforts.	Reducing the associated 'costs' will make operator decision making easier and increase the likelihood further that the safest recovery actions will be taken promptly in an upset situation.	
C	Operators are **not fearful** of **reprimand** if they **wrongly initiate 'costly' recovery** actions as long as they felt **justified** to do so.	There is a blame free culture which reinforces the message that safety has top priority and 'if in doubt' take the safest course of action if you feel justified.	
W	When **plant performance targets** are **discussed** and **reviewed** (such as environmental targets), a **reminder** is **nearly always** given that **safety** is **paramount** and must take **priority** when in **doubt**. This gives **operators confidence** their **superiors** fully **understand** the **'cost'** of recovery actions.	There is usually reinforcement of the importance of safety when talking about other plant performance targets which strengthens the safety culture and encourages operators to consider safety first when deciding on recovery actions.	
X	**Reminder**s are **seldom** given to operators that **safety** must take **priority** when in **doubt**. Operators are given **more frequent** reminders of **targets** for **production / quality / environment**.	There is a lack of active reinforcing of the top priority of safety compared to other plant performance targets which weakens the organisational safety culture and does not encourage operators to put safety first when deciding on recovery actions.	
Y	Although it is **acknowledged** that **recovery actions**, such as emergency shut-down, can result in **significant damage**, etc., there is a **belief** that **operator actions** in an **upset** or **emergency** situation will **not** be **affected** by the **knowledge** of these **'costs'**. There is **no rehearsal** of **scenarios** to **test** such **beliefs**.	There is a lack of understanding by management that operator actions may be affected by them knowing the associated 'costs' or consequences of recovery actions and lead to hesitation and delay.	
Z	**Recovery actions** can result in **significan**t loss of product, equipment damage, etc, but these **'costs'** are **not taken into account** in the development or revision of emergency response **procedures**. **Operators** feel they **alone appreciate** the **'cost'** of recovery actions. **Operators** feel their **management** either **do not understand** the 'costs', or **avoid discussions** about the 'costs'.	Poor practice, staffing arrangements do not fulfil any of the rungs above.	

MANAGEMENT OF OPERATING PROCEDURES (ORGANISATIONAL FACTORS)

Introduction

To progress beyond the acceptable line on the ladder for management of operating procedures it is necessary to demonstrate that the **procedures** are accessed **close to point of use** and are presented in **a clear, concise manner** with **checklists** and other **job aids** for **critical operations.** .Further explanation of the progression towards best practice is provided with each ladder.

Operators

1. Are you familiar with all or some procedures?
2. How often do you consult them, please give examples?
3. Were you trained using them, how were they used?
4. Do they reflect what you do, please explain?
5. Are they:
    a) Current?
    b) Correct?
    c) Understandable?
6. Who writes them?
7. When are they updated (e.g when a change occurs and/or after a specified time period)?
8. Who is responsible for controlling procedures?
9. Are operators involved in procedure writing, please provide examples?
10. Are procedures received by operators before they are approved and made formal, please explain process used?
11. Are procedures provided for significant process changes, please provide examples?
12. Are procedures audited to ensure that they are still current?

Management

1. Who is responsible for managing/controlling operating procedures?
2. Are procedures part of a site quality control system, please explain system?
3. How are procedures updated and out of date procedures recalled?
4. Who approves procedures?
5. Are procedures audited and who does it?
6. Is the procedure QC system reviewed and improved, please explain how?

Documents

1. Operating procedures showing date issued, author, approver, version number
2. Quality manual detailing how procedures are managed
3. Operating procedure audit results

Ladder assessment

Grade	Description	Explanation of progression	Rationale supporting assessment
A	Information on **best practice** is **pro-actively shared** between production units and sites	Further evidence of a learning organisation keen to share its experiences and learn from others.	
B	The **procedure quality control system** is subject to **review** and **continuous improvement**.	Evidence of a learning organisation committed to continuous improvement	
C	There is a **comprehensive procedure quality control system** which the **operations team** is an **integral part of** and which ensures that **procedures** are **recalled** and **updated** when there is **any process, equipment** or **staff** change which necessitates it.	Procedures are managed and incorporated in the management of change process. The importance of operator involvement to encourage ownership and therefore active use of procedures is encouraged.	
D	The **operations team** are **responsible** for ensuring that **procedures** are **up to date** and reflect **current best practice**.	Further encourages ownership and should help to ensure procedures are updated and reflect best practice as it continuously improves.	
E	**Existing procedures** are **audited regularly** to ensure they represent **current best practice** used by the operating teams.	It is recognised that practices vary across shift teams and working practices may change with time. Auditing ensures unsafe or poor practices are identified and rectified, encourages continuous improvement and ensures the operating procedures are living, active documents.	
F	**Operators** are part of the **procedure writing team** and **all operators** are **fully trained** in **new procedures** and given the **opportunity** to **provide feedback** on the procedures **before** they are **approved** and made **formal**.	It is recognised that operator involvement will increase ownership and reflect working practice. This will encourage active use and operator generated updates.	
G	The **procedures** are accessed **close to point of use** and are presented in **a clear, concise manner** with **checklists** and other **job aids** for **critical operations**.	Procedures have been designed to be used and it has been recognised that providing checklists and other job aids will encourage use and help to reduce errors in application. They also prevent operators generating their own job aids which may become out of date as they are uncontrolled.	
X	It is **clear** which **procedure** should be used for a **particular task** or **situation**. **All information** required for a **particular task** or **operation** is **kept together** and is **easily referenced**.	No duplication of procedures, therefore no confusion about which is the correct version. Are acceptable and operators can rely on the accuracy of the information.	
Y	**New procedures** are provided for **significant process changes**. There is a **quick run through** given **to operators** when the procedures are **introduced**.	No operator training for new procedures, even for significant process changes. Small process changes or changes in work practice are missed and procedures tend to ‘drift’ out of date over time.	
Z	**Procedures** were written **several years ago** and there have been **few** if any **changes**. There is **no evidence** of **procedure quality control system**. **Operators** play **no part** in the **writing**. There is a **quick run through** of procedures given **to operators when** they are **introduced**.	Poor practice, staffing arrangements do not fulfil any of the rungs above.	

MANAGEMENT OF CHANGE (ORGANISATIONAL FACTORS)

Introduction

To progress beyond the acceptable line on the ladder for management of change it is necessary to demonstrate that a for a **planned equipment**, **procedure** or **organisational change**, a **gap analysis** on **skills** is carried out and **resources assigned** for **training prior** to the **change**. The **impact** of the **change** on **emergency response** is **assessed** and **included** within the **gap analysis** and **training programme**. Further explanation of the progression towards best practice is provided with each ladder.

Operators

1. Can you think of any examples where there was a significant change to process/procedures/people which affected CR or field operation, please describe?
2. Were you aware of the planned change before it was introduced, how did you learn about it?
3. Were you consulted /involved in planning the change, please explain?
4. Was a transition phase used to ease the change, please describe?
5. Was there a review after implementing the change, please describe?

Management

1. Are there guidelines or is there a policy for managing changes to process/procedures/people, please describe?
2. How is organisational change managed (particularly changes in control room staff, control room support staff, field operators, support field operators)?
3. Where CR operation is affected, are CR operators involved and similarly where field operation is affected, are field operators involved?
4. Are the safety implications assessed of proposed changes, please provide examples of where this occurred for:
    a) Equipment changes
    b) Procedural changes
    c) Organisational changes?
5. Are there examples where proposed changes have been abandoned if it is found that safe CR or field operation is compromised, please describe?
6. Are transition phases used, please describe?
7. Is there a review programme after change is implemented, please describe?

Documents

1. Procedures for managing equipment, procedural and organisational change
2. Organisational change policy document
3. Evidence of review after implementing change

4. Evidence of change (equipment and organisational) being risk assessed

Ladder assessment

Grade	Description	Explanation of progression	Rationale supporting assessment
A	There is a **review programme** after **change** is **implemented**. The extent and number of review steps is dependent on the significance and scope of the change.	The need for review is appreciated and the form of the review is determined through the management of change process.	
B	Where possible, **transition phases** are used to ease the change and ensure that **safety** is **not compromised. If** the transition phase shows the **planned change** is likely to **compromise safety** (through operator experiences, near misses, dangerous occurrences) the **change** is **reversed**.	The benefit of transition phases is recognised and the management of change process seek to identify whether once can be used. The phase is used to assess safety and makes a reversal of the change easier if it is required.	
C	A **gap analysis** on **skills** is carried out and **resources assigned** for **training prior** to the **change**. The **impact** of the **change** on **emergency response** is **assessed** and **included** within the **gap analysis** and **training programme.**	Additional skills are identified and put in place prior to the change and includes those required for normal and emergency situations.	
W	The **key people affected** by the **change** are **identified** by **analysing** the **effects** of the **change** and are **consulted** during the **change management process** and their **views** are **respected**.	People affected are correctly identified and form core consultees during the process. Their views are incorporated into the process and not ignored.	
X	The **decision to change** is **reversed** if it is found that **safe CR or field operation** is **compromised**.	The risk assessment process has the ability to recommend that a proposed change is abandoned and the team are not pressurised into allowing the change to take place.	
Y	Any **equipment, procedure** or **organisational change** is **assessed** for **safety implications** and the **risks systematically assessed**. The **assessment team** is selected based on **skills** and **knowledge**	Evidence of risk assessment forming part of the management of change process for all changes. The risk assessment team is specific to the change.	
Z	**Operators** are **not part** of the **change management team**. There is **no assessment** of **how safety** may be **affected** by proposed **changes** and **no transition phase** to help **manage** the **change**. There is **no review** after the change to check its effectiveness.	Poor practice, staffing arrangements do not fulfil any of the rungs above.	

CONTINUOUS IMPROVEMENT OF SAFETY (ORGANISATIONAL FACTORS)

Introduction

To progress beyond the acceptable line on the ladder for continuous improvement of safety it is necessary to demonstrate that **investigations** from **incidents / abnormal events** are **used** in the **review** of **training needs and operating procedures**. Further explanation of the progression towards best practice is provided with each ladder.

Operators

1. Is there a mechanism for suggesting improvements?
    a) How are they raised/discussed/recorded, please describe process?
    b) Are they assessed and then implemented?
    c) How are they assessed and then implemented?
2. Are operators involved in reviewing incidents, please provide examples?
3. What type of incident is reviewed (e.g. major incident, minor incident, dangerous occurrences, near misses)?
    a) How is it done, please describe process?
    b) Are the results fed back to you, please explain how?
4. Is CR and field operation reviewed against safety performance measures, please explain how?
    a) Are operators involved?
    b) How is it done?
    c) Is product quality reviewed for indications of operational problems, please provide examples?
5. Do you consider incidents reported from other plants and incorporate lessons learned, please provide examples?

Management

1. Is there a policy of continuous improvement which incorporates CR and field safety, please describe?
2. Who is responsible?
3. Who is involved?
4. How are improvements suggested, assessed, implemented?
5. What type of incident is reviewed (e.g. major incident, minor incident, dangerous occurrences, near misses)?
    a) Who does it?
    b) How?

c) What is done with the output?

6. Is CR and field operation reviewed against safety performance targets?

    a) Who does it?

    b) How do they carry out the review?

    c) Is product quality used as an indicator, please explain how it is used?

    d) Are other plants used for learning opportunities, please provide examples?

    e) Do you share your learning with others, please provide examples?

Documents

1. Site safety policy
2. Safety statistics
3. Incentive scheme details
4. Graphs displayed on noticeboards
5. Output from continuous improvement initiatives
6. Company wide literature with safety information included (safety improvement initiatives and safety performance figures)

Ladder assessment

Grade	Description	Explanation of progression	Rationale supporting assessment
A	The **organisation** is **proactive** in **sharing** its **learning** with **others**.	The organisation seeks to share its experiences with others to improve safety at other sites.	
B	**Incidents** reported from **other plants**, particularly plants with **similar processes** and **control room arrangements**, are **screened** for possible **lessons**. **Learning opportunities** are then **explored** and **identified** in a **structured manner**.	The continuous improvement process is not restricted to on-site events and seeks to maximise learning opportunities by using the experiences of other plan ts.	
C	**All aspects** of **control room** and **field operations** are **reviewed periodically** and **constructively** with the **involvement** of **operators**. The **review** is **not restricted** to **incidents/near misses** but **includes** a **review** of parameters, such as **product quality**, **productivity**, that could **indicate operational problems**.	There is a proactive approach to improving operational safety which incorporates parameters such as productivity and product quality. It is an ongoing process involving operators.	
D	When **changes** are made in **control room or field operations** they are **reviewed** after **three** to **six months**.	The need for review after changing operating practices is recignised.	
E	**Investigations** from **incidents / abnormal events** are **used** in the **review** of **training needs and operating procedures**.	There is active incorporation of lessons learned from incident investigation into training needs and operating procedures so the lessons can be translated into reality.	
V	The **lessons** from **incidents / abnormal events** are **formally briefed** to **all operators** and they are given an **opportunity** to **comment** on the **analysis**.	Operators have an opportunity to comment on the analysis of incident investigation.	
W	**Incidents** and **abnormal process events** are **analysed**, with the **immediate** and **root causes identified**. **Operators** are **involved** in the **analysis**. **How** the **incident could** have **developed** or **could** have been **responded to** under **different process** or **operational conditions** is **considered** and **explored**. **Lessons specific** to the **scenario** and **general** to **other conditions** are **drawn out**.	There is good use made of incidents/abnormal events for learning opportunities and operators are involved.	
X	**Formal guidance** is given on **what type of incidents / abnormal events** qualify for **investigation**.	It is clear which incidents should be investigated.	
Y	**Unusual** or **severe** incidents and **near misses** that are **not** thought to have **happened before** are **reviewed**. The **circumstances** are **recorded** and a **limited analysis** is undertaken. **Operators** are **told** the **results** of the **investigation**, perhaps in the form of **briefing / memo/ instruction**.	There is only limited use of incidents for learning and no operator involvement.	
Z	**Operators** are **relied on** to **raise problems** and make **suggestions** for **improvements**. **Issues** are discussed **informally** between **operators** and their immediate **management / supervisors**. **Comments** are noted in the **shift log** or **equivalent** at the **discretion** of **operators**.	Poor practice, staffing arrangements do not fulfil any of the rungs above.	

MANAGEMENT OF SAFETY (ORGANISATIONAL FACTORS)

Introduction

To progress beyond the acceptable line on the ladder for management of safety it is necessary to demonstrate that the **site safety committee investigate** issues brought to the **meeting**, **assigns actions** and then **tracks actions** at subsequent **meetings**. Further explanation of the progression towards best practice is provided with each ladder.

Operators

1. Are you familiar with site safety policy and performance, please describe?
2. How has it been communicated to you?
    a) Training?
    b) Briefing?
    c) Safety committee?
    d) Noticeboard?
    e) Other? Please define
3. Are you involved in:
    a) Safety committee?
    b) Incident investigation?
    c) Writing safe operating procedures?
    d) Safety auditing?
    e) Improving your area's safety performance?
    f) Other? Please define
4. Are you aware of safety initiatives in other production areas or sites, please describe?

Management

1. Who is responsible for managing site safety policy?
2. How do you apply it?

a) Safety committee?
b) Auditing?
c) Continuous improvement in areas?
d) Performance targets?
e) Compare performance with other units, sites?
f) Other? Please define

3. Who is involved?

4. Do you encourage site employees to experience other sites' methods of working, please provide examples?
5. How do you benefit from this?
6. How is the production area and site performance communicated to employees on site and across sites?
7. Do you share your learning and safety management methods with others, please explain how?
8. Is safety integrated with quality and environmental management systems, please explain how?

Documents

1. Site safety policy
2. Audit reports, action plans
3. Performance monitoring graphs
4. Evidence of safety management system
5. Safety committee minutes
6. Continuous improvement team output
7. Company wide literature with safety information included (safety improvement initiatives and safety performance figures)

Ladder assessment

Grade	Description	Explanation of progression	Rationale supporting assessment
A	The **organisation** is **proactive** in **sharing** its **learning** and **safety management methods** with **others**.	The organisation seeks to share its experiences with others to improve safety management and policy implementation at other sites.	
B	**Operators participate** in **continuous improvement teams** which **tackle safety** as well as **quality** and **environmental improvement**. Any **ideas** the **teams have** can be **implemented** based on **costs** and **benefits**. **Results** of **changes** are **reviewed** and **communicated** to **other area teams**.	Safety is part of an integrated management system which aims for continuous improvement across all areas. Operators are an integral part of the process and ownership is encouraged through their ideas being implemented. Ideas are shared across areas.	
C	The **organisation** has a **clearly defined safety policy** across **all sites** and **clear targets** for sites to aim for. **Site** and **company safety performance** is **communicated** across **all sites** via company literature and **improvement ideas transferred**. **Site employees** are **encouraged** to **experience other sites method**s of **working** to **standardise sites** and **share improvement ideas**.	There is a strong organisational safety culture and sites are expected to continuously improve. There are opportunities for sharing improvement ideas across sites with the goal being to improve performance across the whole organisation. Benchmarking best practice sets clear targets for sites to aim for.	
D	The **site** has an **integrated safety policy** with **safety performance monitored** in **each site area**, **results** and **trends communicated** to the **entire si**te and **improvement targets set**.	Continuous improvements in safety performance is monitored in each site area so trends can be tracked and improvement actions defined in an area specific way. This improves the transparency of individual area performance and allows credit to be given for good performance and poorer areas to be targeted.	
E	**Site safety audits** are **regularly** carried out, **operators** form **part** of the **auditing team** and **participate** in **analysing** and **reviewing** the **results** and drawing up **action plans**.	Operators are highly involved in implementing the auditing part of the site safety policy and therefore have good awareness of safety issues and the requirements of the policy.	
F	The **site safety committee investigate** issues brought to the **meeting**, **assigns actions** and then **tracks actions** at subsequent **meetings**.	The meeting is used to generate actions and ensure they are completed to improve safety performance.	
W	**Site safety audits** are **regularly** carried out. **Operators** are **not** included on the **auditing team**. **Results** are **communicated** back **via** the operators' immediate **management/supervisors**.	There is auditing to monitor the effectiveness of the site safety policy however operators are not involved. Results are communicated by line management.	
X	**Safety performance targets** are written into **individual job objectives** for **operators**, **supervisors** and **managers.**	Every individual has a formal responsibility for site safety.	
Y	The **site** has a **safety committee** for which **operators** have a **representative(s).** The **representative** can take any **issues** from the **operating team** to the **safety committee** for discussion. **Outcomes** from the meeting are **communicated informally** via the **safety representative**s.	There is limited operator involvement in site safety policy and no formal communication to the entire operations team.	
Z	**Operators** are **not directly involved** in **site safety policy** and are **not included in incident investigation, safety committees** or **establishing safe operating procedures**. There **is no communication** of **site** or **area safety performance**. Any **involvement** is **informal** and takes the form of **verbal communication**.	Poor practice, staffing arrangements do not fulfil any of the rungs above.	

APPENDIX C

Case study 1

Case study 1

Site introduction

The site was a greenfield site when it was built approximately eight years ago and its working practices have emphasised workforce involvement and continuous improvement from start-up.

The major hazards for the site are associated with natural gas or hydrocarbon liquid leaks and the potential for fire and explosion.

The site is surrounded by other major hazard sites and SSSI area and so has to be able to deal with an emergency which may be caused by an off site event.

Process operation introduction

The blast proof control room controls two trains and has a full DCS. There are two screens dedicated to each train plus a screen dedicated to the event log.

There is always a minimum of one operator technician present in the control room. On shift there are three operators in total, there is no supervisor. During the day (8:00 - 16:00) there are five operator technicians carrying out repairs or preventive maintenance tasks. The pool of 28 plant operator technicians are responsible for plant operation, maintenance and improvement projects. The shift pattern uses 20 people on a 20 week rolling rota and eight operator technicians are available for project work. The shift team who are on from 6:30 - 13:00 are responsible for issuing work permits in the morning. All the operator technicians are trained to operate the control room as well as work outside on the plant, therefore the three shift operators can vary their work during a shift.

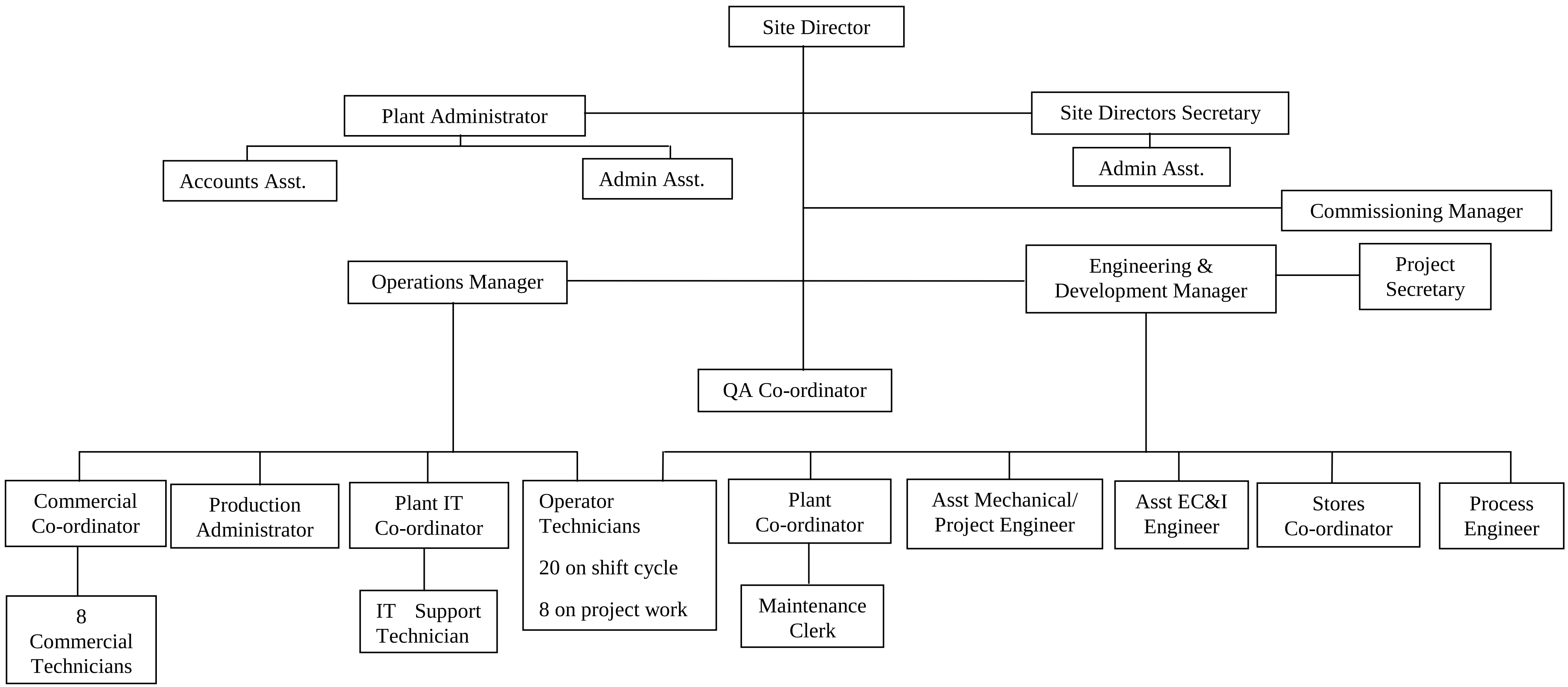
There is always a minimum of one commercial technician located in the control room in a different section to the DCS console. They are trained to assist during an emergency by answering phones to allow the operator technicians to concentrate on the plant.

The shift pattern for the site is attached. An operator technician does a 60 day shift cycle covering plant operation followed typically by 17 days off then a four week block of plant maintenance working 8:00 - 16:00, 2 days off followed by the next block of plant operation. The composition of the plant operations and maintenance teams is not fixed as each technician works his own shift pattern.

Site organisational structure

Figure 1 summarises the site's organisational structure.

Figure 1: Site 1 Organisational Structure



The operations manager, assistant mechanical and assistant electrical engineers all started on site as operator technicians and progressed into their current jobs. There are currently 8 operator technicians seconded onto days for project/maintenance work. These technicians are additional to the number required on the shift pattern to run the plant.

Individuals involved in case study

During the case study the following people participated through interview or completing parts of the method themselves:

- 8 operator technicians
- 1 commercial technician
- plant administrator
- operations manager
- QA co-ordinator
- health and safety advisor (operator technician transferred to Health and Safety department)

The operations manager and HSE advisor were given copies of the ladder assessment questions to make notes on and copies of the ladders to place the process operation on. The other people were interviewed on the ladder questions and several of the operator technicians went through the physical assessment method for identified scenarios.

Assessment results

A worked example of the physical assessment is shown in Figure 2. The physical assessment was done for fifteen scenarios and the results are summarised in Table 1.

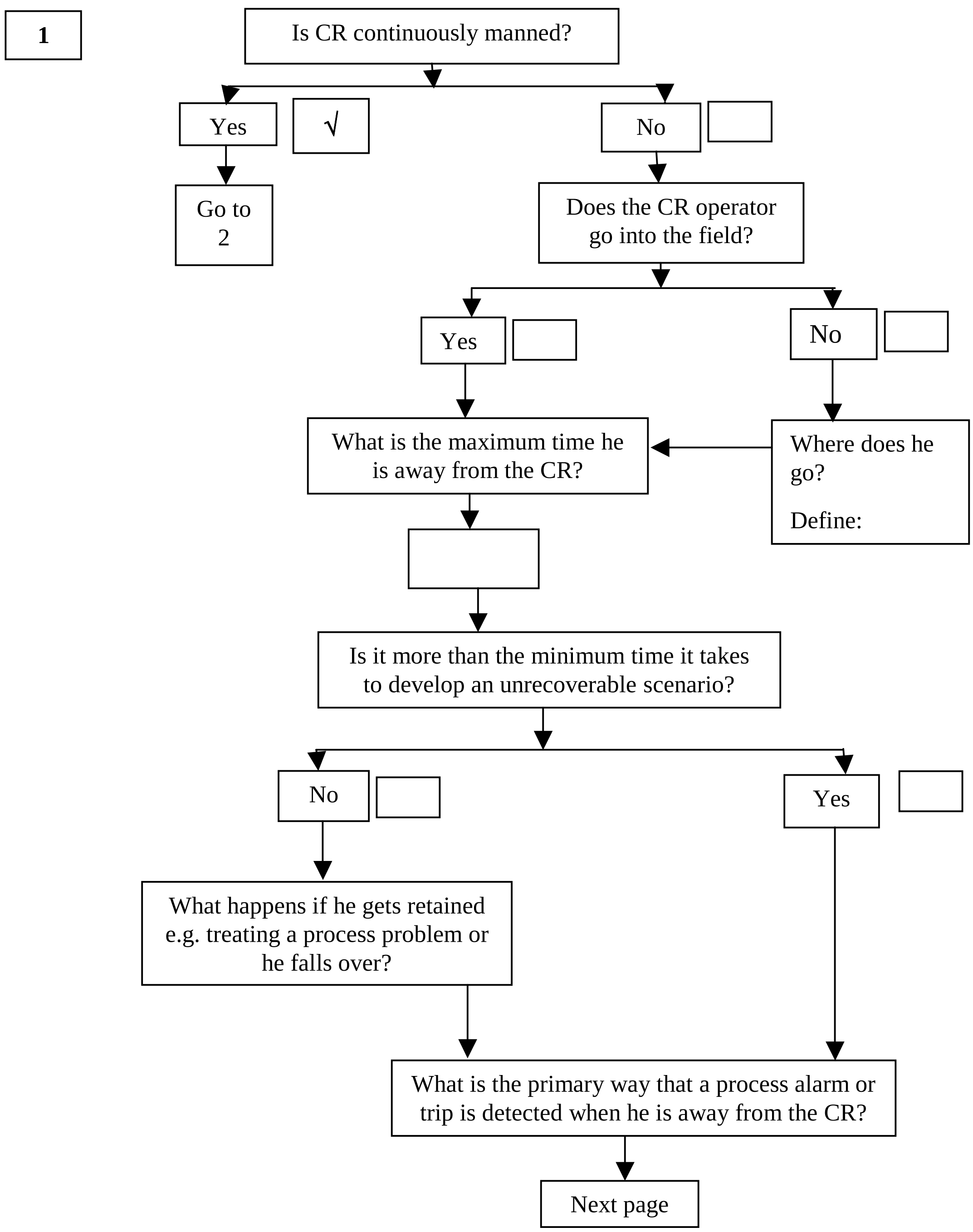
Physical assessment

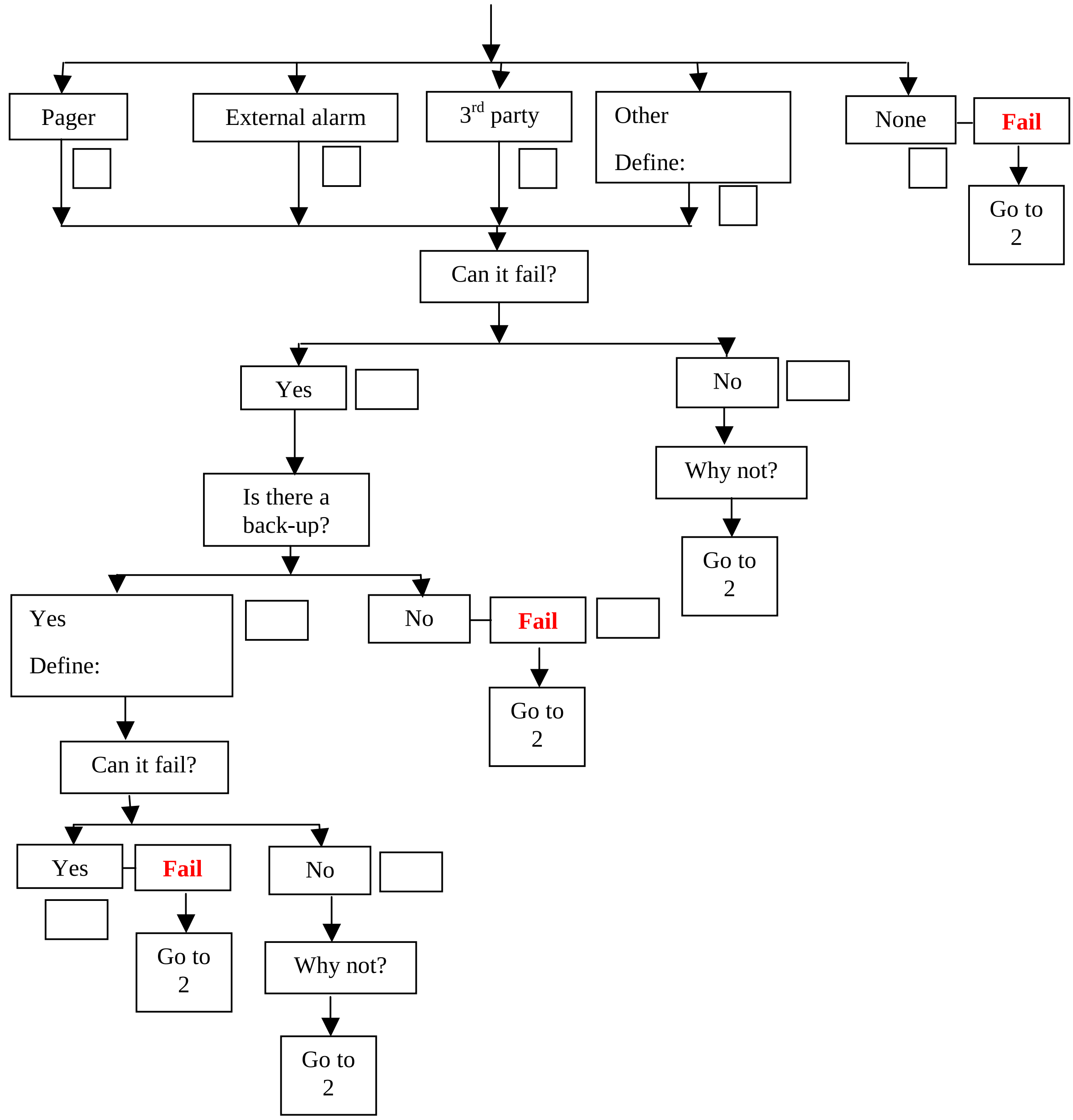
Scenario number: 1

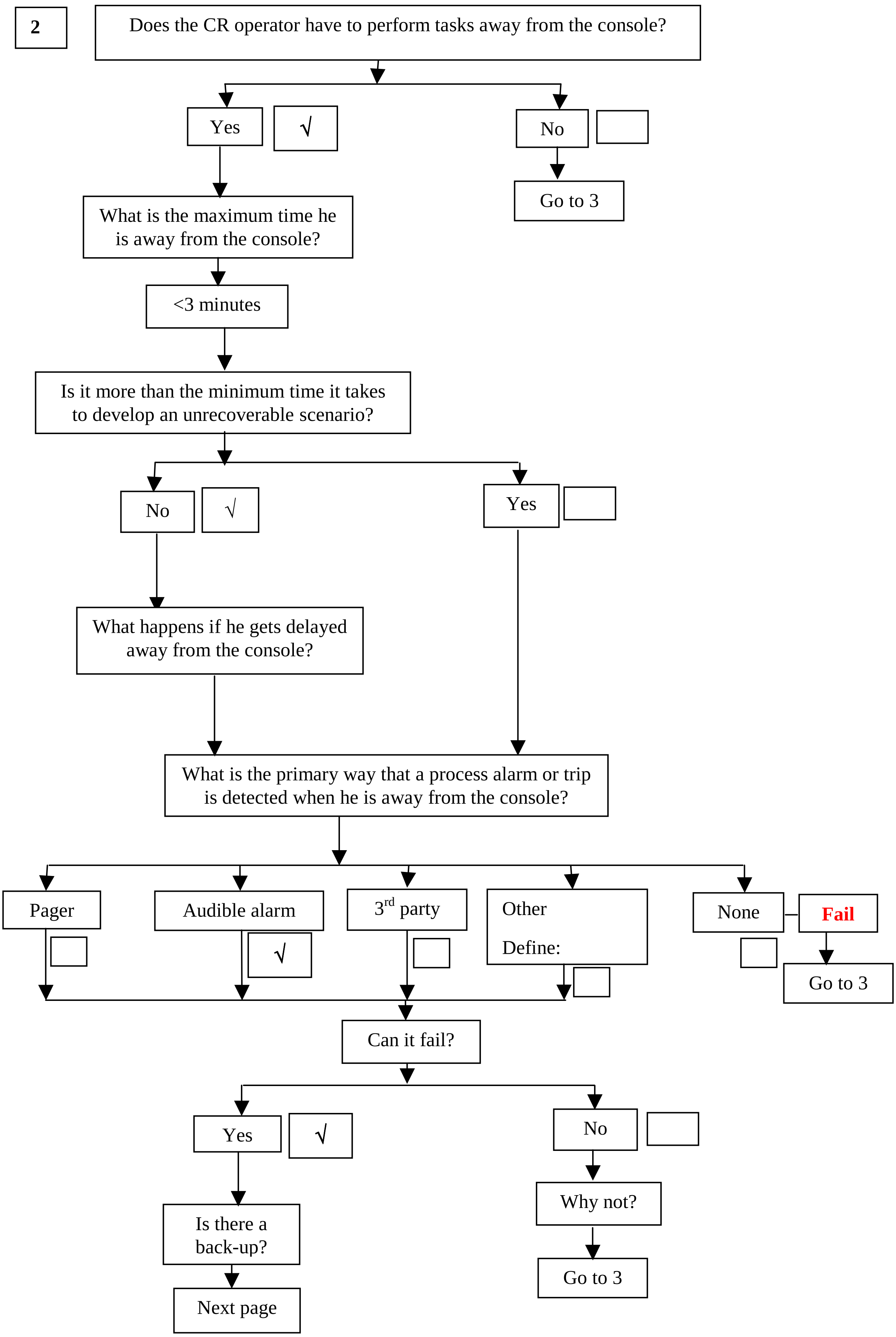
Description: Gas leak during day shift during the week

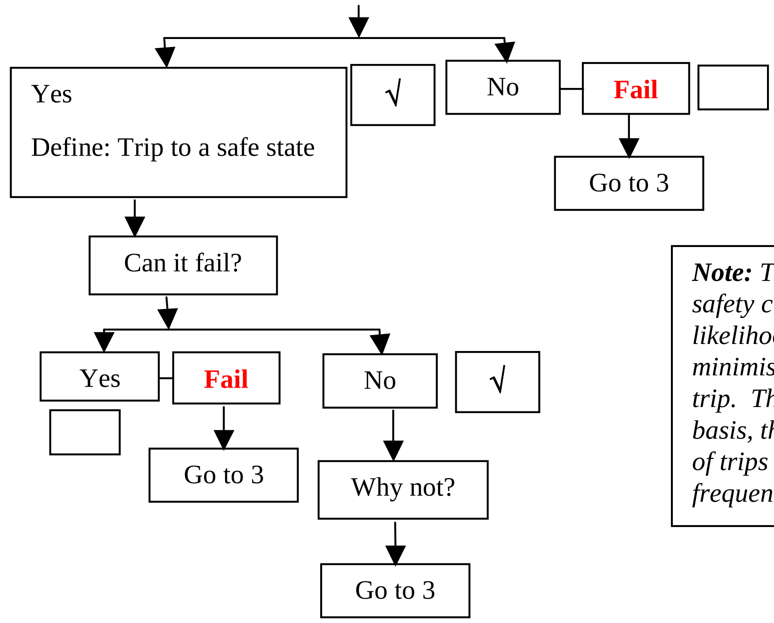
Number of historical incidents: 2. One in 2000, an instrument pipe sprung out from the compression fitting. One in 1998 from an exchanger.

How much time have you got?: <30 minutes

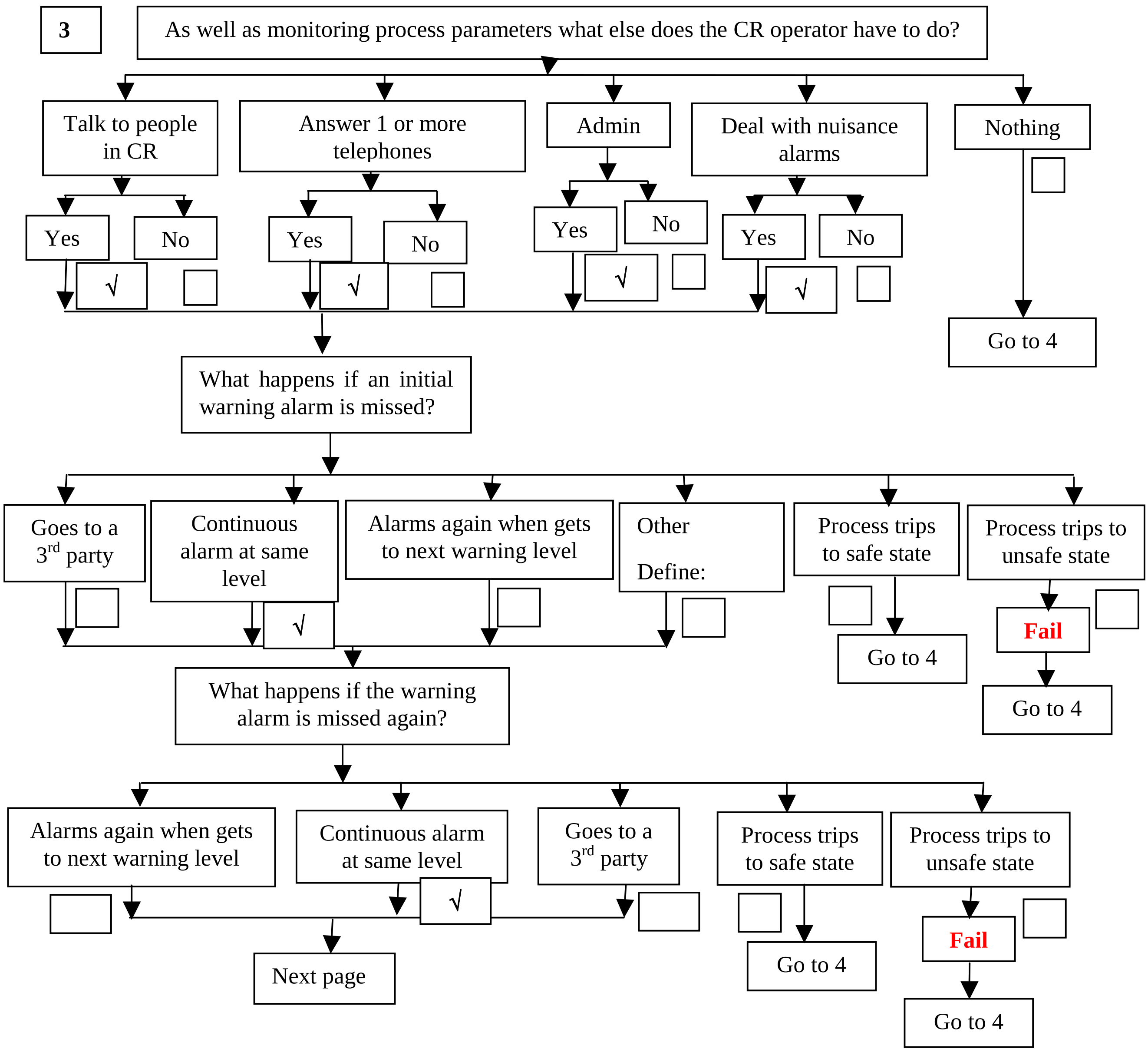


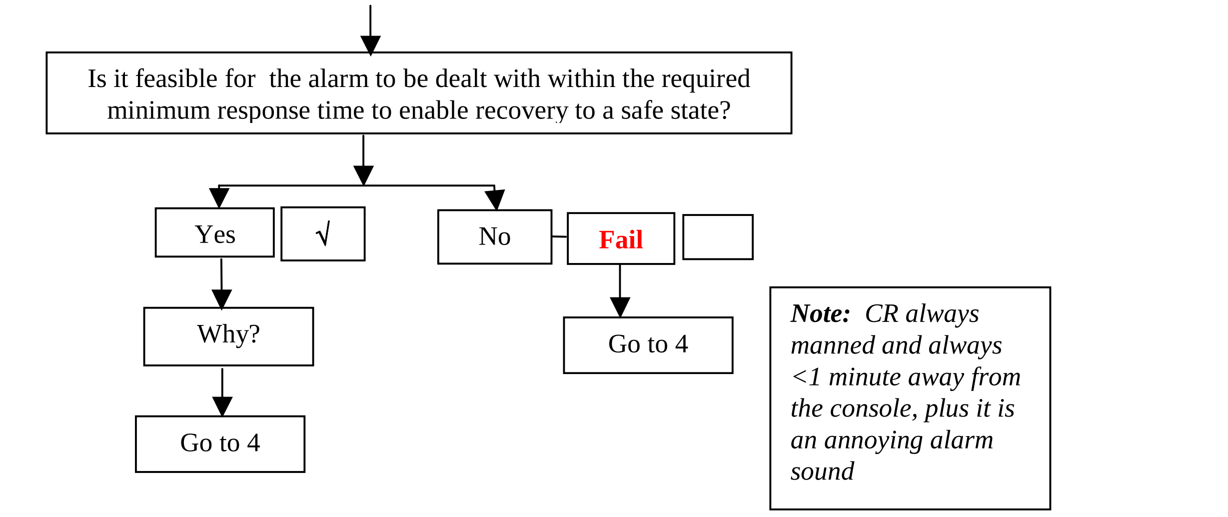

Pager
External alarm
3rd party
Other
Define:
None
Fail
Go to 2
Can it fail?
Yes
No
Why not?
Go to 2
Is there a back-up?
Yes
Define:
No
Fail
Go to 2
Can it fail?
Yes
Fail
Go to 2
No
Why not?
Go to 2

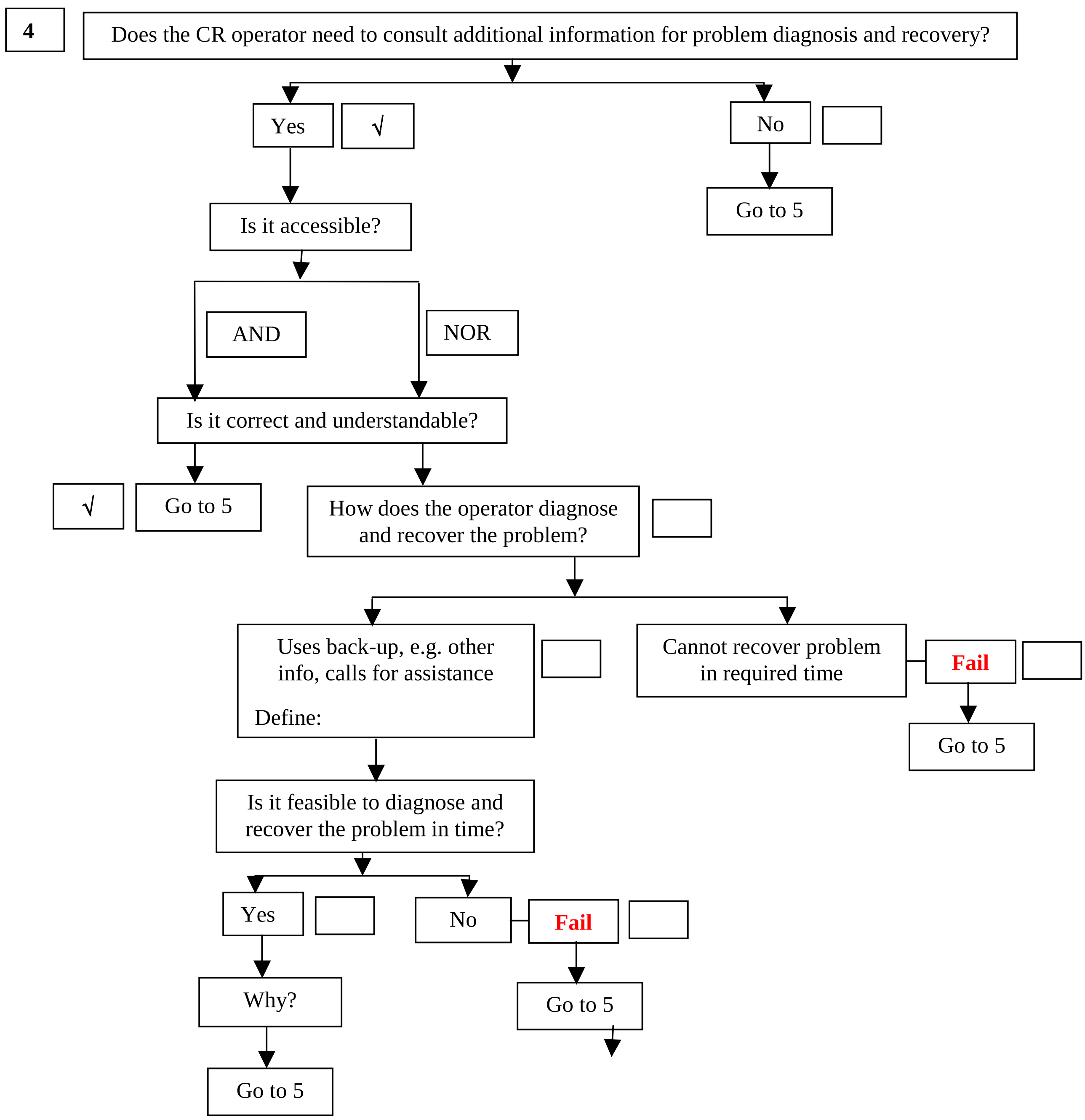

2
Does the CR operator have to perform tasks away from the console?
Yes
√
No
Go to 3
What is the maximum time he is away from the console?
<3 minutes
Is it more than the minimum time it takes to develop an unrecoverable scenario?
No
√
Yes
What happens if he gets delayed away from the console?
What is the primary way that a process alarm or trip is detected when he is away from the console?
Pager
Audible alarm
√
3rd party
Other
Define:
None
Fail
Go to 3
Can it fail?
Yes
√
No
Is there a back-up?
Next page
Why not?
Go to 3

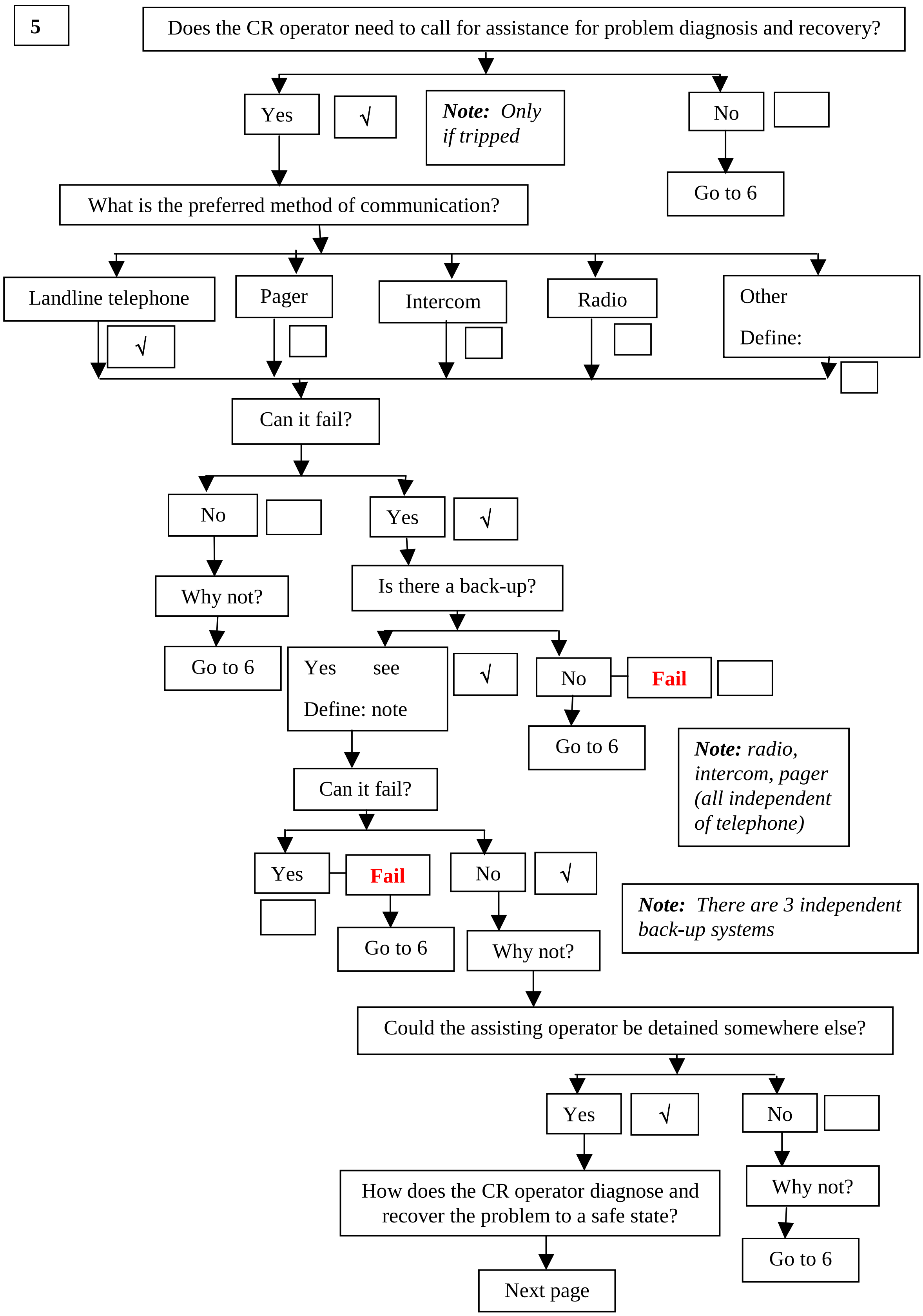


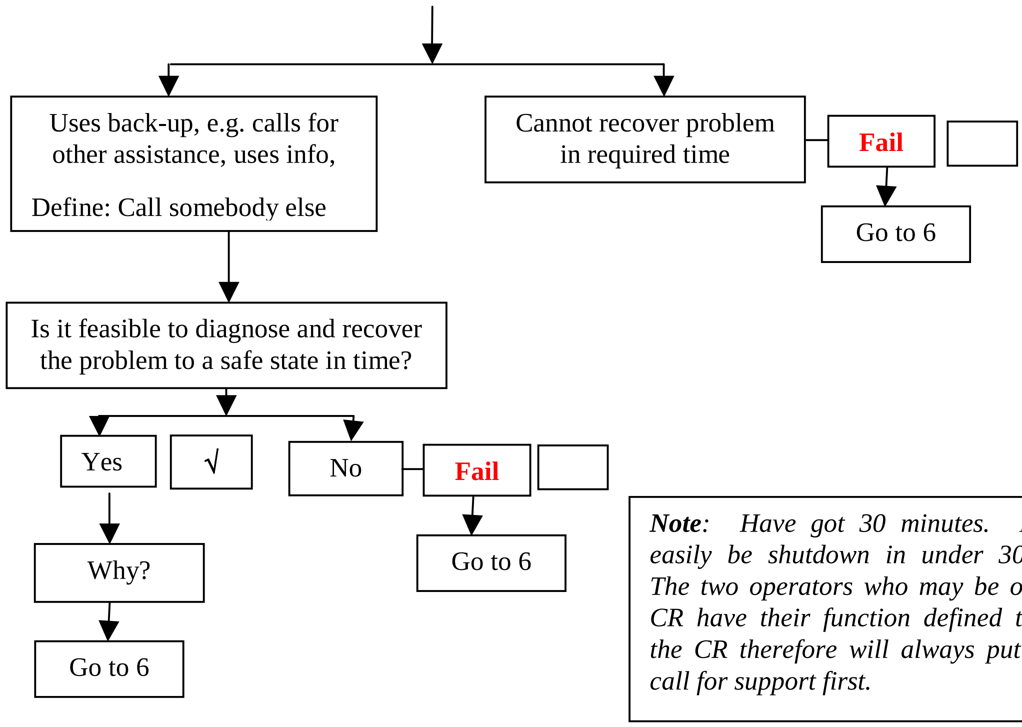
Note: *There is 2 out of 3 voting logic on safety critical items and therefore the likelihood of failure of the device is minimised. Redundancy is built into the trip. The trips are tested on a monthly basis, there is a review of the frequency of trips and this informs the test frequency*



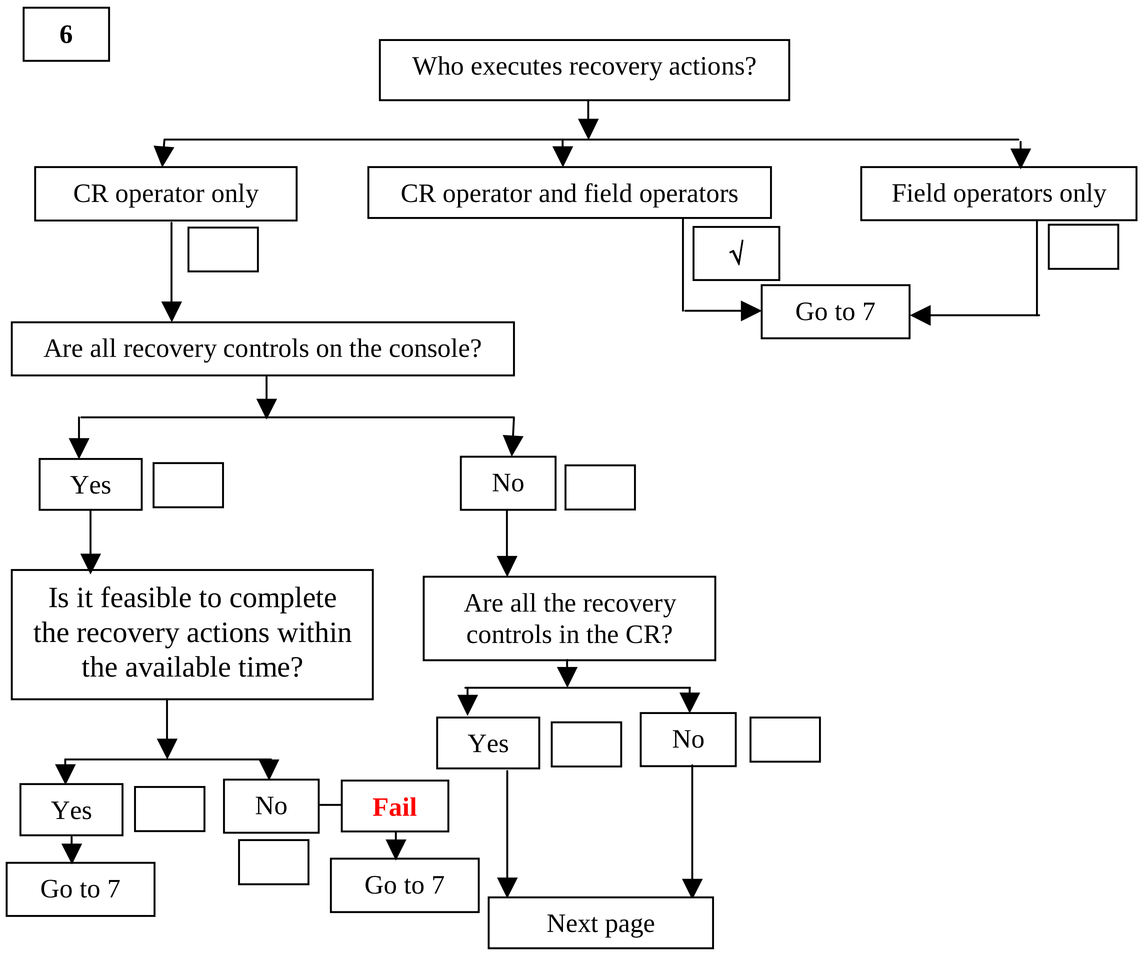

Is it feasible for the alarm to be dealt with within the required minimum response time to enable recovery to a safe state?
Yes
√
No
Fail
Why?
Go to 4
Go to 4
Note: CR always manned and always <1 minute away from the console, plus it is an annoying alarm sound

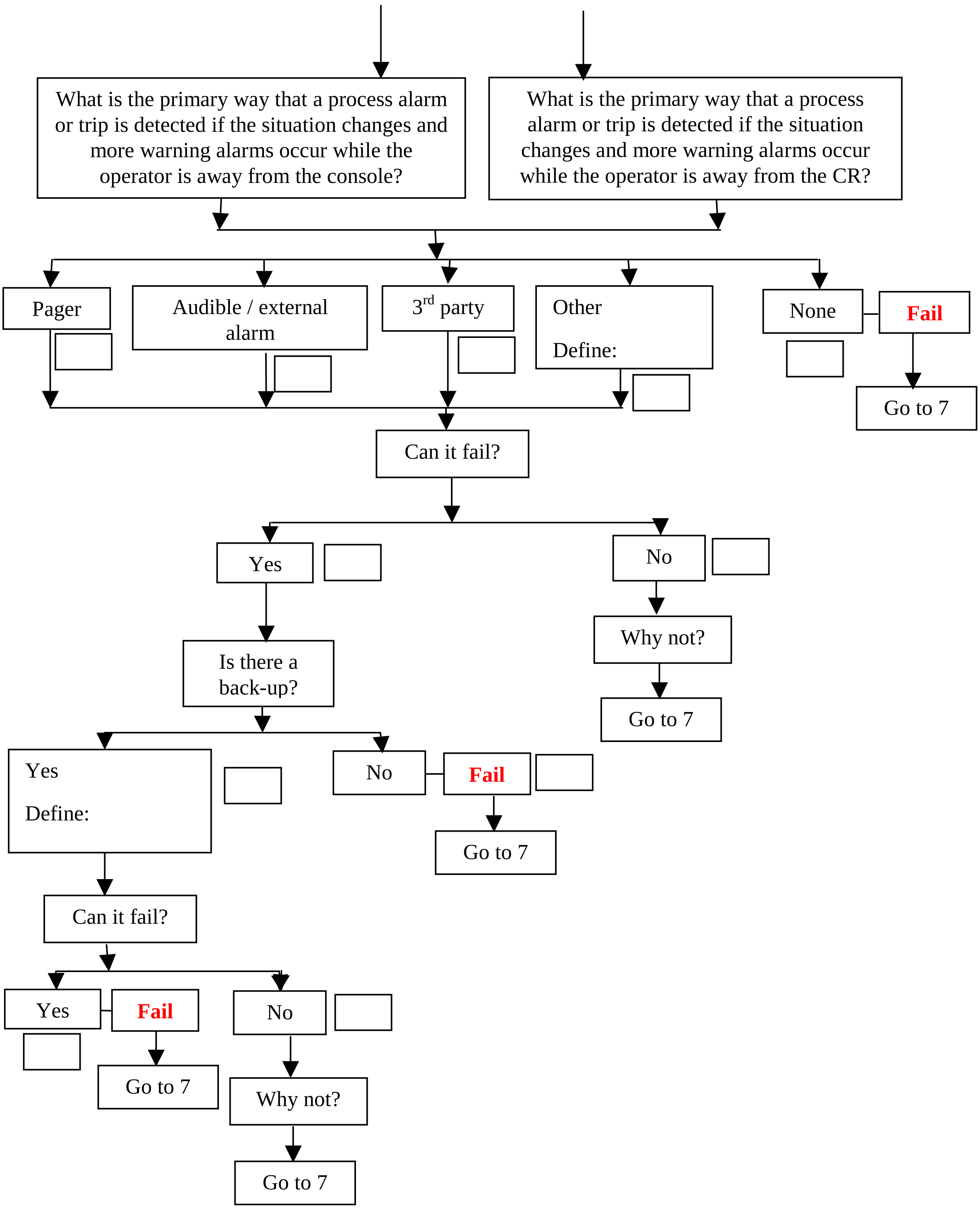

4
Does the CR operator need to consult additional information for problem diagnosis and recovery?
Yes
√
No
Go to 5
Is it accessible?
AND
NOR
Is it correct and understandable?
√
Go to 5
How does the operator diagnose and recover the problem?
Uses back-up, e.g. other info, calls for assistance
Define:
Cannot recover problem in required time
Fail
Go to 5
Is it feasible to diagnose and recover the problem in time?
Yes
No
Fail
Why?
Go to 5
Go to 5

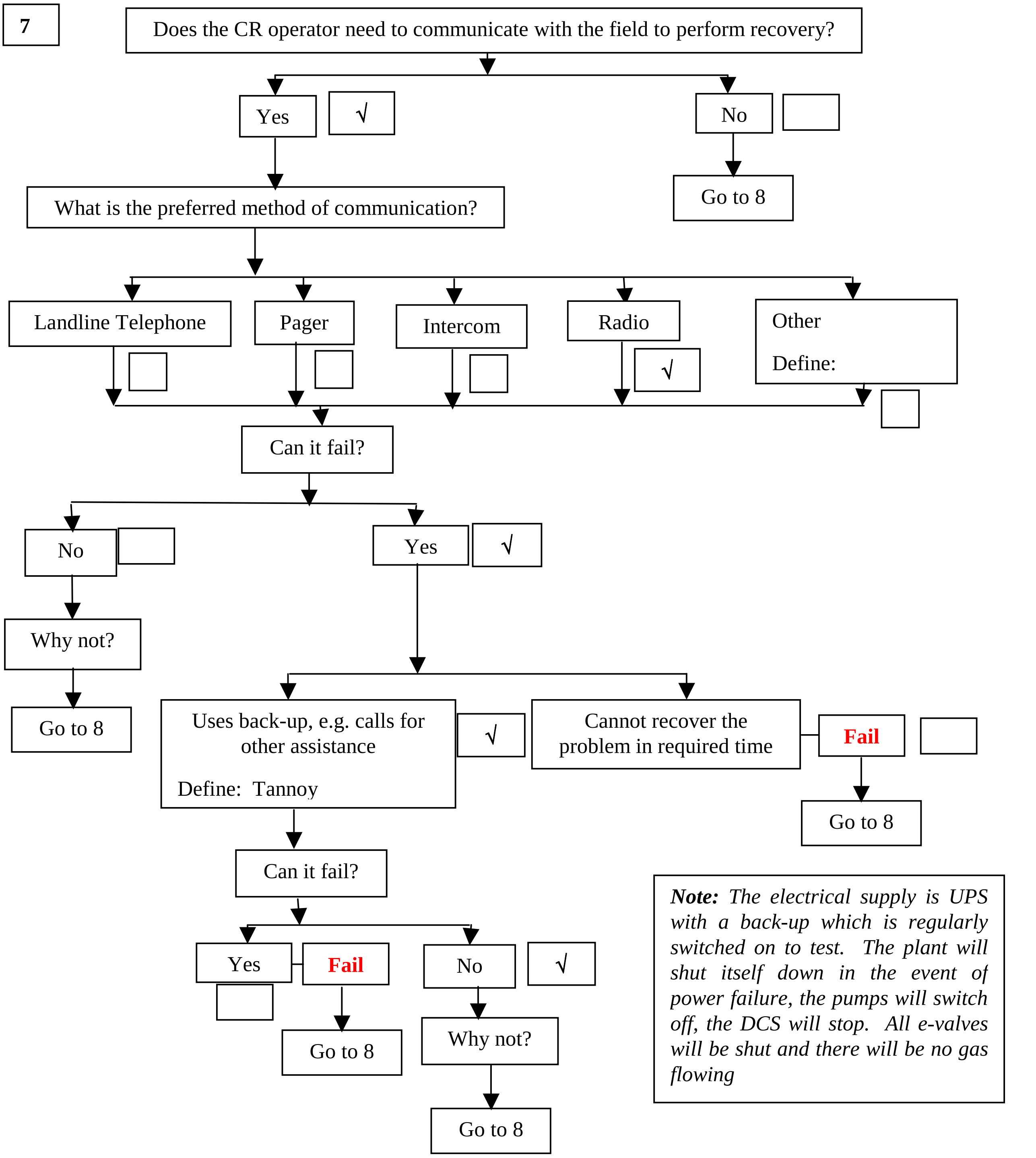

5
Does the CR operator need to call for assistance for problem diagnosis and recovery?
Yes
√
Note: Only if tripped
No
Go to 6
What is the preferred method of communication?
Landline telephone
√
Pager
Intercom
Radio
Other
Define:
Can it fail?
No
Why not?
Go to 6
Yes
√
Is there a back-up?
Yes see Define: note
√
No
Fail
Go to 6
Note: radio, intercom, pager (all independent of telephone)
Can it fail?
Yes
Fail
Go to 6
No
√
Why not?
Note: There are 3 independent back-up systems
Could the assisting operator be detained somewhere else?
Yes
√
No
How does the CR operator diagnose and recover the problem to a safe state?
Next page
Why not?
Go to 6



Note: *Have got 30 minutes. Plant can easily be shutdown in under 30 minutes. The two operators who may be outside the CR have their function defined to support the CR therefore will always put the CR's call for support first.*




What is the primary way that a process alarm or trip is detected if the situation changes and more warning alarms occur while the operator is away from the console?
What is the primary way that a process alarm or trip is detected if the situation changes and more warning alarms occur while the operator is away from the CR?
Pager
Audible / external alarm
3rd party
Other
Define:
None
Fail
Go to 7
Can it fail?
Yes
No
Why not?
Go to 7
Is there a back-up?
Yes
Define:
No
Fail
Go to 7
Can it fail?
Yes
Fail
Go to 7
No
Why not?
Go to 7



Note: *The electrical supply is UPS with a back-up which is regularly switched on to test. The plant will shut itself down in the event of power failure, the pumps will switch off, the DCS will stop. All e-valves will be shut and there will be no gas flowing*

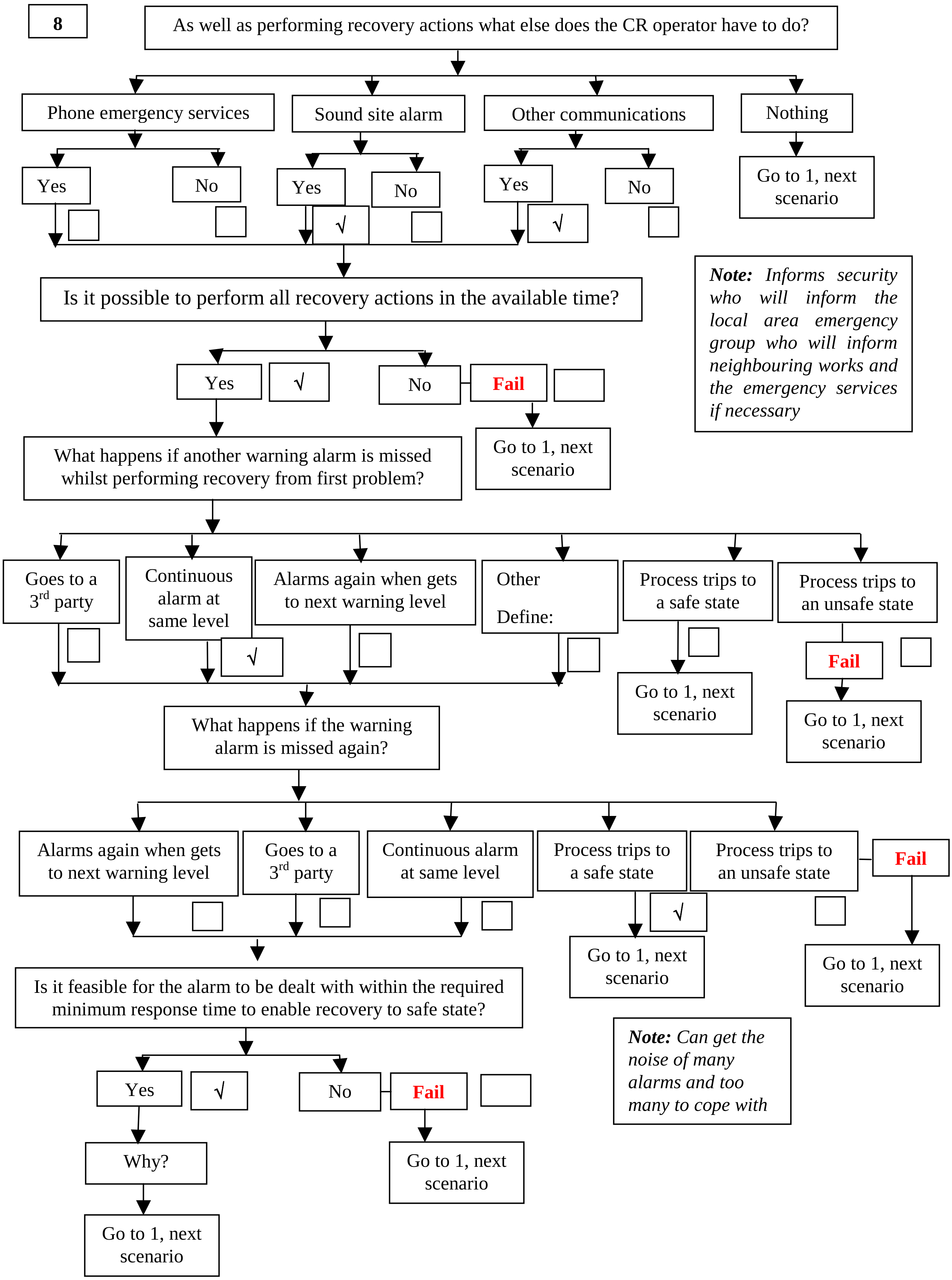

8
As well as performing recovery actions what else does the CR operator have to do?
Phone emergency services
Sound site alarm
Other communications
Nothing
Yes
No
Yes
√
No
Yes
√
No
Go to 1, next scenario
Note: Informs security who will inform the local area emergency group who will inform neighbouring works and the emergency services if necessary
Is it possible to perform all recovery actions in the available time?
Yes
√
No
Fail
Go to 1, next scenario
What happens if another warning alarm is missed whilst performing recovery from first problem?
Goes to a 3rd party
Continuous alarm at same level
√
Alarms again when gets to next warning level
Other
Define:
Process trips to a safe state
Go to 1, next scenario
Process trips to an unsafe state
Fail
Go to 1, next scenario
What happens if the warning alarm is missed again?
Alarms again when gets to next warning level
Goes to a 3rd party
Continuous alarm at same level
Process trips to a safe state
√
Go to 1, next scenario
Process trips to an unsafe state
Fail
Go to 1, next scenario
Is it feasible for the alarm to be dealt with within the required minimum response time to enable recovery to safe state?
Yes
√
No
Fail
Why?
Go to 1, next scenario
Go to 1, next scenario
Note: Can get the noise of many alarms and too many to cope with

Table 1 Summary table for Site 1 physical assessment

Scenario #	Scenario Description	PASS	Fail	Physical assessment #('s) failed on	Actions required
1	Gas leak during a day shift during the week	√			None
2	Gas leak during an evening during the week and during the day or evening at the weekend	√			None
3	Gas leak during the night in the early morning	√			None
4	Gas leak and fire (high pressure, 150m jet fire) during a day shift during the week	√			None
5	Gas leak and fire (high pressure, 150m jet fire) during an evening during the week and during the day or evening at the weekend	√			None
6	Gas leak and fire (high pressure, 150m jet fire) during the night in the early morning	√			None
7	Gas leak, fire and explosion during a day shift during the week	√			None
8	Gas leak, fire and explosion during an evening during the week and during the day or evening at the weekend	√			None
9	Gas leak, fire and explosion during the night in the early morning	√			None
10	Pipeline fracture with gas release during a day shift during the week	√			None
11	Pipeline fracture with gas release during an evening during the week and during the day or evening at the weekend	√			None
12	Pipeline fracture with gas release during the ght in the early morning	√			None
13	3rd party toxic gas release during a day shift during the week	√			None
14	3rd party toxic gas release during an evening during the week and during the day or evening at the weekend	√			None
15	3rd party toxic gas release during the night in the early morning	√			None

Therefore no potential areas of unacceptable risk were identified from the physical assessment and no improvement actions identified.

The ladder assessment results for site 1 follow. There are summarised responses from interviewing plant personnel on the assessment questions for each element, and the ladders have been completed to indicate assessed position based on the interviews, observations while on site and information gained from reviewing site documents. The operations manager and HSE advisor completed the ladders after answering the assessment questions and their judgement of the site position is indicated within the assessment ladders and the rationale for the assessed position explained. Not all the questions have been fully answered, this is due either to time pressure or the unavailability of personnel (such as human resources, occupational health) to verify the site's policies.. However all the operator's questions have been answered and input was gained from the operations manager, QA co-ordinator and plant administrator on most management questions. In a full study, further investigation would take place plus documentary evidence would be referred to in question responses

Table 2 summarises the control room's performance on the ladder assessment elements and suggests improvement actions

<u>Ladder assessment for case study site 1</u>

1 or more control room operators have contributed to the operator questions. The management questions were generally answered by the Operations Manager, where someone else has contributed, it is indicated. Documents were also seen and reviewed as part of the assessment but not all the documents listed at the end of each section. The documents in italics were seen during the assessment. The bold position in the ladder indicates the control room's current, assessed position. The position of the acceptable/unacceptable line in the ladders is subject to further review.

SITUATIONAL AWARENESS (WORKLOAD)

<u>Operators</u>

1. Can you think of any examples of critical situations where you were uncertain about the state of the process, please provide details? *Yes, front end cross-over gas flow*

    a) Have you delayed actions in order to obtain information about the process? How long for, typically? *Yes, 3-4 minutes maximum (1st operator). Yes, 5-10 minutes when had an exchanger gas leak, knew process conditions and people went out on site to check the gas detectors in case it was a false alarm (2nd operator)*

    b) Have you misdiagnosed a situation? *No, because do (a) before take action. Make sure it is right and which of the possibilities it is.*

2. How do you monitor process trends, please explain? *Through control room DCS screens for major plant trends, can trend any parameter, there is always one screen devoted to each train, always showing and always an alarm screen showing. There are 2 screens per train*

3. How do you decide when to take action to improve a process condition (e.g. through initial process warning alarms, from tracking plant conditions etc)? *Experience and technical knowledge, feedback from DCS. Rates of change, difference between normal status and what is shown (1st operator). If the process is heading towards a fault or unsafe conditions then would take action. A process alarm will come in when should be taking action. Will look at other parameters to support and check one bit of information (2nd operator)*

4. How do you track plant conditions during:

    a) a shift? *DCS, trends*

    b) a day? *Logs, written for shift handover. There is a daily plant instruction and information book (red book) which contains things for staff on maintenance*

    c) a week? *Sheets, there is a long term operational issues whiteboard which is updated daily*

5. What do you do to make shift handover easier for the shift coming on to understand the plant condition? *Written logs, handover section, verbal communication. The shift coming on signs off that the handover is complete but it may just be 1 to 1 whereas three people actually come on. The 'strong' operator is given the handover information and talk*

Observations: Changeover from afternoon to night lasted over an hour, went through shift's events verbally. The new shift came in one at a time spread over approx. 1 ½ hours to relieve the previous shift. Change over from night to morning was spread over approx. 30 minutes, all shift events gone over verbally, tended to come in at around the same time and was much quicker.

6. How easy do you find it to access process monitoring information with regard to:

    a) Finding the correct screens? *Easy, once you know the way round them*

    b) The presentation of the screens? *Good, each train is a different colour so can easily differentiate, the best two colours that could be found were used but one colour is not ideal for reading*

    c) The reliability of the screens? *Very good*

System has own alarms internal to DCS

7. How would you like to improve the screens (e.g. presentation, more trends, refresh rate, ability to adapt displays) *In an ideal control room all of them, including more screens, increased duration of trends. Train 1 trends is on an old DCS and the historical refreshing could be improved so it is similar to Train 2. Plus it is not the easiest DCS for setting scales, it takes 2-3 minutes to change a scale and therefore during that time you cannot be looking at trends*

8. How frequently are you disturbed in the middle of tracking process conditions? *Depends on the time of day. The plant does not run flat and requires continuous modifying to meet output targets. The target can change every hour due to the main user changing as they are always adjusting their load. Each shift normally gets a change in output target, a trend is forecasted at the start of the day but it is likely to change. There is a lot of potential for disturbances (especially during the day) and the screens can be tied up by auditors, visitors, plant tours. However there is always somebody to monitor the trends and the plant will always take priority*

    a) By what? *Contractors returning permits, see above also*

9. Can you schedule activities so that you are able to concentrate on particular tasks until complete, please explain? *Yes*

10. Can you block non critical radio/telephone communication if required, please explain? *Yes, divert calls, but might not be advisable (1st operator). No, there is no way of differentiating between general and process communications. During a site emergency, all calls coming through would go to the Incident Room (on site or one of the identified alternatives)*

11. Have there been critical situations when you have been uncertain of the location or activity of field operators, please explain? *During a trip situation, high noise levels can cause a problem with radio communication. Yes, you can be uncertain of their location as they are on plant, doing logs, it is a round walk route, can*

use the radio to find out where somebody is. Operators will not leave the control room without saying where they are going. Operators only take a radio if they are going on plant and also if one person is going to be left in the control room then they will take a radio

Management

1. How are process conditions monitored? *DCS*
2. Are there any guidelines as to what to monitor and how often, please describe? *Constant monitoring via DCS, shift readings*
3. How is a shift handover managed to maintain situational awareness? *Half hour handover session, shift log, shift summary, operations instruction book and long term issues board*

Documents

1. *Logbooks*
2. Event reports
3. *Standing instructions, operating procedures, incident control plan*
4. Training and development programme: *Induction, modules, basic skills training, safety training*

Ladder assessment

Grade	Description	Rationale
A	**There is high level of continuity in the Operator(s) tasks during critical process events, i.e. Operators are not required to perform tasks that significantly disrupt their concentration on the process, and they are able to delay / bring forward other activities in order to minimise distractions.**	**Operations manager's view of control room's position and this reflects the evidence collected on how operators can delegate non-critical tasks to the commercial technicians and can delay or bring forward other activities to minimise disruption.**
B	During critical process activities that demand the operator's attention, they are not disturbed unnecessarily by other activities such as mustering, site alarms, telephone/ radio communications, permit raising, issuing of interlock keys, visitors etc..	HSE advisors view. Operations manager commented that the main distractions are the number of DCS alarms and the number of telephone calls, both of which make communication become difficult. When there is an incident, the operators are encouraged to use logs to keep track of actions taken and when, during the incident.
C	In upset and emergency conditions all relevant Operators and Supervisor can gauge accurately and reliably the condition and behaviour of the plant, within the available time, without disturbing each other or blocking each other's access to information.	
D	The presentation of information makes it straightforward for Operators to gauge accurately and reliably within the available time the condition and behaviour of the plant in normal and upset / emergency conditions, without reliance on support.	
X	It is possible for operators to keep track of the process during upset / emergency conditions if they work hard to gather all relevant information from control room displays / log books. There can be times when they rely on other operators/ field operators relaying key information to them.	
Y	Information about the process and plant condition is adequate for operators to be confident they can monitor 'smooth' running	
Z	Operators find it difficult to keep track of the process even in smooth conditions. This may be due to insufficient information, unreliability of sensors or displays, or they cannot attend to the process because of other tasks they are required to perform, or distractions.	

TEAMWORKING (WORKLOAD)

Operators

1. Are support staff available to the control room (CR), who are they? *Yes (technical and admin during day, admin during night, need to call out technical if require further assistance)*
2. Where are they based? (e.g in CR, on site within production unit, different production unit) *Within CR commercial technicians, either within CR or on plant for other 2 members of shift operations team. On plant or in CR for operators (during week days) on maintenance duty*
3. When are they used? (e.g times of high activity for problem solving and recovery or for start-up) *Plant upsets, trip situation*
4. What do they do? (e.g. answer phones, provide technical assistance, help to re-start the plant) *All except the commercial technicians provide operations support as they have the same skillbase and are qualified CR operators. The commercial technicians can assist during incidents by dealing with phone calls and administration (1st operator). During a major incident, the plant administrator and site director's secretary would answer phones either on site or at another site a few miles away. All the phones to site can be redirected to the other location. (Plant administrator)*
5. Have dry runs been used to check that the CR can recover in time, what did they demonstrate? *No*
6. Is the ability reviewed in the event of changes? *No but event reports are used to assess improvements which can be made.*

Support staff

1. What are your normal duties when you are not required in the CR? *Commercial technicians: Monitor export orders and advise London of potential commercial opportunities or problems. In London there are traders, gas logistics team who take a countrywide view of the market. Others: Form part of operator technicians team either operating plant or maintaining it*
2. Is your role defined to support the CR as part of your function? *Yes for all. Admin staff (Plant administrator, site director's secretary) are designated as support staff in the Incident Control plan and plant administrator is responsible for the Admin Building and there are two identified reserves if she is not in (Plant administrator) Commercial technicians: in normal duties, talk quite closely with operators as some things are not possible so always check with the operators. Plus operators advise on any problems hitting export targets or general problems on plant that could have commercial impact. In emergencies, we are the main telephone contact point for most customers who know to contact commercial rather than the CR operators. Commercial contact everyone who needs to be contacted. In critical safety situation we are on the phones, if it is not a critical safety situation then we can input available capacity into spreadsheets so we can adjust exports.*

3. What do you do when you are required to support the CR? *Commercial technicians: See 2 above Others: Whatever is required as part of the operator technician team. Admin staff, make sure food is available, answer phones, admin duties, passing information, contacting people, take calls (Plant administrator)*

4. Have dry runs been used to check that the CR can recover in time, what did they demonstrate? *Do operational tabletops where go through something happening on plant and practise a scenario, operator technicians take the lead and commercial attend (it is a roleplay exercise). Also do commercial tabletops where commercial technicians take the lead and operator technicians attend. It is not assessed specifically but operators have a good idea how individual commercial technicians would react in a situation plus the commercial manager has a good idea.*

Have operation guidelines for running the plant normally, got plant trip procedures which gives the role for the commercial technician, operations technician and main customer's site manager. Also have a checklist on what to do in an Excel workbook for a train trip or total incoming gas supply trip. There is no formal technical training but in the commercial procedures there is a lot of technical detail (although not to the same standard as for the operators)

Management

1. Are the roles and responsibilities of support staff defined? *Yes*

2. Does training and dry runs take place to ensure that the CR can recover in time from major hazard scenarios? *Incident control is practised. Tabletop exercises go through potential scenarios.*

3. Is the ability reviewed in the event of changes? *No*

Documents

1. *Operating procedures*

2. Definition of roles and responsibilities

3. Job descriptions for CR staff and support staff

4. Training and development programme

Ladder assessment

Grade	Description	Rationale
A	Any changes to process, procedures or staff initiate a review of the operations shift team's ability to recover the plant to a safe state within the available time.	Operations manager's view of where the control room sat, for equipment and procedure changes there are HAZOP's and design reviews. There was no evidence of a method for assessing the effect of CR staff changes on the CR's ability to recover to a safe state.
B	**It has been proven by past incidents/dry runs that the operations shift** team **can recover the plant to a safe state within the available time. Support staff may be required for re-start up and are on-call for this.**	**HSE advisors view of where the control room sat. Past incidents have been recovered by CR staff. If the plant is shutdown outside of daytime hours, support staff are called in for start-up.**
C	The operations team is multi-skilled in mechanical, electrical and instrumentation aspects of the plant as well as control room and outside plant operation	Yes operations team cover operations and maintenance and modules cover process, mechanical, electrical and instrumentation skills.
D	The operations team is multi-skilled in control room and outside plant operation	Yes there is job rotation between the three operators during a shift and are and assessed trained in all aspects
E	Support staff are available within the CR. They can perform either admin/communication tasks or may provide extra technical assistance. Their support role is defined and part of their function.	There are always commercial technician(s) (minimum of 1) available to deal with phones and admin tasks.
F	Support staff are available outside the CR in that plant area. Their role is defined to support the CR when required and is part of their function.	There is always a minimum of one operator in the control room, there may be 2 or 3 depending on the time of the day and the tasks required outside on plant. When an operator is in the field he is contactable by radio and tannoy and his priority is to assist the CR operator.
X	Support staff are available on different areas of the site and are only available if that process can spare them.	
Y	Support staff are available on call-out for recovery. It is assumed that they will arrive in time.	
Z	There are no support staff available. It is assumed that the CR staff will cope with all scenarios.	

ALERTNESS AND FATIGUE (WORKLOAD)

<u>Operators</u>

1. Do you sometimes feel sleepy when operating the CR? *Yes*

   a) When? *Times of less activity, during night shift, 3-4 am or dinnertime if I have been out the night before*

   b) How frequently? *Every night shift*

   c) What do you think causes it? (e.g. boring tasks, poor lighting, temperature, humidity, long shifts, mornings/afternoons/nights) *Temperature, humidity, nights*

   d) What do you do to try to combat it? *Do a plant tour*

2. Do you sometimes miss alarms, please give examples of where this has happened? *Unusual during normal operations, it is possible during a trip*

3. Does it take you longer to recognise and respond to plant conditions on certain shifts, please give examples of were this has happened? *Yes, in the middle of the night*

4. Do you swap shifts? *Yes*

   a) How often (e.g. how many times in a month)? *Once a month (1st operator), occasionally (2nd operator)*

5. Do you work overtime? *Only when shift requires it i.e. problems on site, outtages. Occasionally if something is going on will stay 1 / 2 hours*

   a) How often (e.g. how many times in a month)? *Difficult to answer*

<u>Management</u>

(Work pattern)

1. Is consideration given to passive versus active tasks in job design? *No*

2. How have lighting and temperature levels been determined? *Feedback from operators. We are limited on what we can do with the building as it is blast proof so we cannot get any fresh air into it.*

Observations: At night there was only lighting in the console area, there were far fewer alarms and all three operators were at the console, the main control room lights were switched back on at around 6am.

3. How was the shift cycle and length determined (i.e. what were the identified requirements)? *It was based on the best operating duration, 8 hour shifts (Operations manager). There were certain parameters used to design rotas around such as length of shifts, how quickly people come back onto shifts, the rest periods between shifts and lengths of blocks of shifts. A consultant generated several alternatives based on these parameters and the operators picked the rota they preferred. The first option chosen the operators found out that they did not like it and it also caused admin problems. The second option chosen worked better for everybody. The site wanted 2 mornings, 2 afternoons and 2 nights so had the longest rest periods between shifts to adjust. We did not want a shift pattern where operators had to come in on an afternoon shift after a night shift. We have got a 20 man, 20 week rolling rota. Have actually got 28 operators and experienced operators are used on projects. 8 operators are used for project/maintenance work and other people cover them while they are on projects.*

The system is self policed and they decide their own start and finish times, they must do the required hours and they do the handover in their own time. Changes are made to the rota to cover sickness and training courses as well as projects they are required to do. The plant administrator plans in the cover required for people on courses and uses day shift people who are nominally on maintenance. She gives a 3 week forecast of day people available to the maintenance planner and can change maintenance people 3 weeks ahead. She gives a final forecast the Wednesday before the following week of the people available so that maintenance jobs can be planned in a week ahead. Maintenance requires 2 operators as a minimum and 4 usually. If desperate then the plant administrator asks someone to come in and do an extra shift.

The newer people are moved around a bit so it is ensured that that shifts have a reasonable amount of experience. Cannot have 1 experienced man and 2 inexperienced so she moves people around so that team are balanced and have sufficient experience. As it is a rolling rota, adjustment is sometimes required to increase the experience. At the weekend a maintenance man can swap a day off for a shift. It is under constant review, a Monday morning report forecasts 3 weeks ahead, problems ahead, who's doing what e.g. courses, projects (maintenance). Operators can do their own swaps as long as they do not abuse the system. Occasionally they do a double shift and rules are that they only do it if it is unavoidable. If it is done on a regular basis then it is picked up and the operations manager will caution the operator. It is largely self-policing. Operators are very good at swapping shifts and letting the plant administrator know. It helps to forge one operations team and irons out personality conflicts which arise.

The 12 month rota is on large charts on the wall and changes are marked up in different colours, orange is a requested shift swap, red is confirmed as OK; green is a private swap.

There were 20 people initially, it expanded to 22-23 as the site needed people for projects and now is 28. (Plant administrator)

4. Is there job rotation during shifts, please explain? *Yes rotate around time on console and time on plant*
5. Is there job rotation during the shift cycle, please explain *Yes spend time in operations and maintenance*

6. Are there restrictions on operators swapping shifts, please explain? *Yes. There is a big issue about 12 hour shifts (another company site runs them) but on this site it is resisted as there are only 3 people and all could suffer from fatigue. They sometimes do 14 hours (morning and afternoon), definitely cannot do nights with morning or afternoon. Are not allowed to do a quick return, night followed by an afternoon. The 3rd night shift sometimes causes problems but it only happens occasionally plus the other two people are not on their 3rd night. The operators have reported that it is really bad to do 2 nights, day off, night; say it is worse than 3rd continuous night shift (it only tends to happen during a shutdown when there are more people around on nights) (Plant administrator)*

7. Are there maximum working hours criteria, please explain? *Yes*

8. Are there minimum rest days criteria, please explain? *No (Operations manager). Yes, the minimum is 2 rest days (one is a sleep day), generally they have 3 rest days or 4 or 5. In total desperation they may only have 1 day off; 2 mornings, 1 afternoon, one day off then 4 shifts but not a full two sets.*

   The first shift pattern chosen had a 6 day block, 2 day block, 6 day block (same number of hours as current system). They chose it for the extra holiday of a week. It eliminated the emergency pool and they only got a 2 day break between 2 blocks plus 1 sleep day each time. It was tried for a year then replaced (Plant administrator)

9. Are there controls on the amount of overtime? *Yes, company contract is 1703 hours, there are 150 annualised hours, operators have 200 annualised operators this year. There is no paid overtime. The extra hours that everybody does are tracked everyone completing a sheet monthly, a spreadsheet is maintained and used to keep track of whether someone is working too many or too few hours. (Plant administrator)*

   a) During normal operation, please explain? *Yes*

   b) During high workload periods such as start-up/shutdown, please explain? *Yes. During shutdown, extra hours are more likely but the same system applies*

(Health)

1. Do you monitor the causes of absence, please explain? *No. There is a medical when people start and every two years VDU users have eye tests and plant personnel have hearing tests. An occupational nurse comes on site every month and individuals can discuss issues with the nurse. If specialist help is required then it is referred through HR and management. (Operations manager).*

2. Do you monitor for signs of fatigue through absence or health monitoring, please explain? *No, see answer to 10. It does get managed and the Plant administrator manages the feedback from operators so she can plan in the cover and can use it to affect the 'favours' which are asked. There is a strong relationship and high levels of trust between plant administrator and operators (Plant administrator)*

3. Do you require operators to report particular types of medication? *No not explicitly, however the question is asked at the annual health check about prescribed tablets but they do not have to inform management*

Observations: The control room is very busy in the morning from 8:00 to 9:30 with issuing permits (although done outside control room within the same building), the doorbell sound indicated someone was at the permit office and someone from the control room would go to sort them out. There were usually 2/3 people at the console although one person was a the console for around 10 minutes. During the day there was often more than one day operator technician in the control room.

Documents

1. *Shift cycle and pattern*
2. *Event reports*
3. Absence records
4. Evidence of health monitoring programme

Ladder assessment (work pattern)

Grade	Description	Rationale
A	**The controls on working pattern (for all operators and individual operators) are reviewed in light of experience**	**Operations manager indicated that this did happen. The plant administrator is the main contact point for operators with concerns or suggestions about the work pattern and she forwards the information to the operations manager. This is then used to prevent causes of fatigue when asking operators to cover other people's shift or when allowing operators to swap shifts.**
B	Operators are able to report concerns they have about fatigue / drowsiness of themselves or others	Is encouraged and the shift pattern is flexible enough to ensure operators are given time recover. Also previous comments are borne in mind when asking people to cover other people's shifts so that the known causes of fatigue are not repeated. Reflects the HSE advisor's view of CR's position
C	It is recognised that operators may require additional rest days after periods of exceptional workload. Flexibility is built into the rostering system to enable this to occur.	As above, can be agreed with plant administrator
D	The amount of time operators are alone in the control room during early morning (0200 to 0600) is minimised. If it is common for operators to be alone at this time, steps are taken to reduce the hazard of the operator drowsiness.	Operations manager commented that the main fatigue is night shift between 04:00 an 05:00. The maximum night shift length is 10 hours
E	There is a limit on the amount of overtime operators can work and individual operator's overtime is monitored to ensure the limit is not exceeded.	Yes 200 paid annualised hours for operator technicians, no paid overtime. Is tracked from sheets filled in monthly to monitor individual additional hours and managers will talk to people doing too many or too few
V	The exchanging of shifts between operators is recorded and periodically reviewed.	
W	The ergonomics of the control room environment mitigate tiredness (lighting, temperature, humidity)	
X	Limits are placed on operator's working pattern, such as: maximum shift length, maximum number of shifts in a sequence, minimum rest time between shifts, minimum rest days per week/month.	
Y	Operators are allowed to work excessive hours without sufficient rest. This includes double shifts and number of days in a row.	
Z	There are no controls on alcohol, drugs etc.	

Ladder assessment (health)

Grade	Description	Rationale
A	The controls on medication (for all operators and individual operators) are reviewed in light of experience (including health monitoring)	
B	**A health monitoring programme is used to monitor for signs of long term fatigue.**	**Not explicitly, rely on operators being able to report any problems to the plant administrator or operations manager although there is an annual health check so there is an opportunity to discuss any issues confidentially. On balance this is a fair assessment as the work pattern is managed and scrutinised on a week by week basis to ensure individuals are not expected to work excessive hours.**
Y	There are clear instructions on the types of medication operators must notify management about	At the annual health examinations, the question is asked about prescribed tablets, however operators are not required to inform management
Z	There are no controls on alcohol, drugs etc.	

TRAINING AND DEVELOPMENT (KNOWLEDGE AND SKILLS)

Operators and covering operators

1. Have you got a training and development plan, what does it include? *Yes, induction, modules, appraisals, off-site simulator training (1st operator). Each operator has a personal copy of the modules and they keep their own master sheet showing which ones they have completed. The modules are linked to pay and there are 17 essential modules that everyone must get, takes about 2 years, sometimes longer. Lead operator has either 17 modules or 2 ½ years experience and he may have a few outstanding modules but he would not get paid until he gets all 17 modules. There are advanced modules beyond the 17 essential ones. The plant administrator keeps a complete set and so do management. Each individual has an appraisal to assess personal needs on top of the blanket section for the plant that everyone has to go through (Plant administrator). Yes 'sort of', got a plan to get so many modules in a year. You go through the modules and are assessed on items by various people e.g. the commissioning manager assesses the process modules and initials them as complete. The plan is to complete 9 modules in a year but can do more if you want to; do the 5 process modules first (as are a process technician) followed by electrical modules, mechanical modules and environmental modules. To get the module information, the P&ID drawings are in one cupboard and can talk to more experienced operators and read their notes and make your own notes. Can use some information while in the control room and have got some spare time (2nd operator, trainee who has completed 3½ modules in 7 months and 3rd operator who has done 17½ modules in 5½ years)*

   Commercial technician: Have three main modules split into ~30 different parts, started writing them in March. It is the first available position due to the opening up of the gas markets. All new starters get a lever arch file and have to work through it and are assessed by questions at the end. It takes ~2 months to do the modules (at the same time as working). There is informal training, we talk to operator technicians e.g. on night shift. In Module 1, cover plant/process overview, Module 2 covers commercial calculations and general market, Module 3 covers more detailed process information.

2. What form did your initial training and assessment take? *Gas processing course (1st operator). There is a week induction when go round the plant and are introduced to the main people on the plant and told what is expected of you in the next months. I have been on two training packages, 1 week on safety and one on high voltage electricity. Training on the process is formal (American consultants come over and run a course for company), he is not been on it yet, it is organised when there are 6/7 people to go (2nd operator). It is an expensive course and everyone goes on it at some point. It is run every 2-3 years. There are two levels, the first run was aimed at engineers and it is now tailored for operators. There are 2 run, one for engineers and one for operators. Get a good reference book from it. (2nd and 3rd operators)*

   Commercial technician: Learned as went through (since 1996), there were no spreadsheets to model how the plant works so had to look at the plant and build up spreadsheets. No-on knew how de-regulation would work. Are self trained, got some help from London on the commercial side and the operator technicians helped on the technical side.

3. Do you get regular refresher training? *Yes for HSE activities, first aid, safety (tabletops, incident control) and fire fighting. New operator has done 2 tabletops. There are operations review days and safety away days. There is additional specialist training in own trade e.g. DCS, high voltage and general training in everything else. Plant administrator has operator training records. Are assessed by a written or verbal test for some courses, complete feedback forms for all courses and 3 months after the course are asked whether it was beneficial. Fire fighting and BA training is done by the fire brigade (2nd and 3rd operators)*

    a) What form does it take? O*ff-site simulator training, tabletops, incident control plant updates, safety away days*

    b) How are you assessed? *Not sure*

   Commercial technician: Normal days can be like a tabletop exercise, in the gas market things do pile on top of each other. Get assessed on modules by either the module writer or the trainer of the new starter (was unsure)

4. What kind of training do you get on major hazard scenarios? *Incident control training at simulator. Tabletops, cover different sections on site, the commissioning manager does them and tracks which ones people attend. They are done on site once a month and you can go if you want to, it is done as a group exercise and you go if you think you need it. At HSE meetings the commissioning manager gives a presentation so everyone is aware of problems. Every year we do a scenario away from site in a simulated control room (are given a scenario). Not assessed on tabletops but are assessed on modules and get asked about things that you did in the tabletop (2nd and 3rd operator)*

    a) How often? *Every 2 years plus tabletops at plant (1 every 3 months on average)*

    b) How are you assessed? *Not*

   Commercial technician: Have tabletops on site and at a hotel (cover most scenarios in these). HSE away days twice a year at a hotel, talk through incidents at other places and near misses at our own site and the company site which is our main customer. HSE meetings monthly where the commissioning manager goes through other incidents. There is no tie in of health and safety to appraisal, commercial technicians stay in the commercial office.

5. Do you get training on new procedures, new equipment or if your job changes, please provide examples? *Yes e.g. emergency diesel generator and air compressors, personnel and time permitting (1st operator). Not really, whoever is in charge of the project issues a pamphlet and it is up to you to read it. It depends on the change, if it is equipment then are given a briefing and there is a set of instructions provided on the equipment. When there is big change then a package is put together of drawings, operating parameters, what to do etc and it may be e-mailed or issued to individuals as packages. (2nd and 3rd operators)*

   Commercial technician: Are told about plant changes and how it will affect the way the plant works, are told about it and get used to it.

<u>Management</u>

1. Who is responsible for CR staff training? *Operations manager and development manager. The plant administrator does the organising*

2. How is the operations team training and development plan structured? *By quarterly review plus at the end of the year through appraisals. Specialist skills are advanced, the basics are always covered. The basic core skills are process modules plus basic instrumentation, basic electrical, basic mechanical.*

3. Are there progressive skill levels for operators to work through, please explain? *Yes, modules, there is a 2 year basic plan.*

4. When and how is training given on process, procedure or job changes? *When required either run internally or externally. They may be a legislative (e.g waste legislation) or a company requirement. People are sent on courses to prepare for job changes. For operator technicians the courses are generally in house but are external where appropriate. Some operators think that there should be more support on the modules as the emphasis is on self-learning*

<u>Documents</u>

1. Training and development plans for control room staff and support staff

2. Evidence of training needs assessment

3. *Evidence of a structure skill step progression programme, module programme*

Ladder assessment

Grade	Description	Rationale
A	**Process/procedure/staffing changes are assessed for the required changes to operator training and development programmes. Training and assessment is provided and the success of the change is reviewed after implementation.**	**Operations manager and HSE advisor's view of control room position. Is supported by evidence below. The HAZOP's and Design Review's identify training needs in the event of equipment and or procedure changes. New operators have to go through the module programme and are supported by two experienced operators until they have completed the basic modules.**
B	All CR operators receive simulator or desktop exercise training and assessment on major hazard scenarios on a regular basis as part of a structured training and development programme.	Yes, both. Tabletop exercises take place every 3 months and simulator training takes place every 2 years.
C	There is a minimum requirement for a 'covering' operator based on time per month spent as a CR operator to ensure sufficient familiarity. Their training and development programmes incorporate this requirement.	Not applicable as every member of the operations team spends time in the control room operating the console every shift.
D	Each CR operator has a training and development plan to progress through structured, assessed skill steps combining work experience and paper based learning and training sessions.. Training needs are identified and reviewed regularly and actions taken to fulfil needs.	Progress through modules, basic and advanced which have an assessment at the end. Additionally there are Safety Away Days, Tabletop exercises, and simulator training on a regular basis where attendance is monitored to ensure all operators receive sufficient training.
W	All CR operators receive refresher training and assessment on major hazard scenario procedures on a regular, formal basis.	
X	New operators receive full, formal induction training followed by assessment on the process during normal operation and major hazard scenarios	
Y	There is an initial run through of major hazard scenario procedures by peers.	
Z	There is no evidence of a structured training and development programme for CR operators. Initial training is informally by peers.	

ROLES AND RESPONSIBILITIES (KNOWLEDGE AND SKILLS)

<u>Operators and covering operators</u>

1. Have you got a job description? *Yes and annual objectives. The objectives set are to look at an area of plant and suggest own improvements for maintenance routines or mods. Or an objective may be to do a mod that someone else has suggested and see through to completion and implementation.*

   Commercial technician: Yes, in case of plant upsets, have a responsibility to keep customers informed and act as a liaison between the control room and outside.

2. Does it reflect what you do? *Yes*

3. Has it changed, is it reviewed regularly? *Yes, reviewed twice a year against objectives*

   Commercial technician: It is reviewed every time site advertises for new staff (~3 /4 times a year). It has expanded a lot since first started and is updated at appraisal every 6 months.

4. Do you know what your tasks and responsibilities are in:

   a) Normal operation, please describe? *Yes, have objectives. Prime role is day to day operations, within that there is preventive maintenance and breakdown maintenance. Some shifts may only have one person who can do permits but everyone works towards it. A senior authorised person authorises and write permits. An operator with an instrumentation background would look particular problems such as dP cell problems*

   b) Emergency situations, please describe? *Yes, incident control plan. Shutdown process if required and make changes. Whoever is at the console is in control. Some shifts have new starters and the operator with the most experience would not leave the control room.*

5. How were these communicated to you? *Appraisals and memo's on operation changes plus through the incident control plan, training, log book and verbally*

   Commercial technician: Learn trip procedures, things happen on a regular basis, regular plant trips, learn by experience.

6. Have they changed and how? *Yes*

   a) Are you assessed against them regularly? *6 monthly*

   b) How are you assessed? *Interview in appraisal and feedback*

   Commercial technician: Not really, more people to contact

7. Is your training and development linked to your role and responsibilities, please explain how? *Yes, operator identifies training that individual requires plus managers provide training that they think individuals require*

   Commercial technician: Yes, training needs assessed at appraisal (focuses on commercial)

Management

1. How was the shift team composition determined, what method was used? (e.g. activity analysis, identification of core competencies) *Multi skilled apprenticeship, look for an engineering linked background, 17 module/9 module/ 5 module are three bands of operators which is a minimum for an operations shift team*
2. What are the core competencies required within the CR? *Defined within modules plus there is a control to ensure that there is sufficient experience on each operations shift team.*
3. Do you reassess the core competencies required prior to changes in equipment/procedure/staff to ensure that they are retained or introduced? There is a need to maintain an *experienced operations team to deal with normal and upset conditions*
4. Are core competencies used in the selection and training and development of operators? *Yes, modules*

Documents

1. Job descriptions for control room staff and support staff
2. Structured assessment of core competencies required
3. *Skill step progression programme which shows evidence of core competencies, module programme*

Ladder assessment

Grade	Description	Rationale
A	**Prior to any proposed change to equipment or procedures the core competencies required for the operations team are reviewed and any new core competencies required after the change are introduced.**	**This is done at the HAZOP and Design Review stage and training is arranged. Operators are involved in site projects as they all have mechanical and electrical competencies as well as process, it is a requirement of the module system. They are a multi-skilled team.**
B	The operations teams are selected and then trained on the basis of the core competencies identified. Operator development is assessed against these criteria.	Module system is used. New operators are selected based on their existing strengths in the module areas (process, mechanical, electrical, instrumentation) and their training and development programme is developed from their existing experience. All operators must achieve the basic modules, there are advanced modules e.g. on the DCS which operators can attain in their core discipline. Every operator is multi-skilled although there is scope for specialisation.
C	There is a management control in place to ensure that core competencies required for the operations team are retained during any staffing changes.	There is a minimum requirement for a shift operations team to have a number of modules. For example if a new operator who had not yet achieved the first five basic modules was on shift then the other two members of the team would have to be very experienced with one ’17 module’ operator and either another 17 module operator or an operator with at least 9 modules. The requirement varies depending on whether it is a night or day shift and during the week or at weekends and is co-ordinated by the plant administrator.
V	Additional roles such as First Aider, Search and Rescue team member are taken into account when assessing the operations team’s ability to cope with normal and emergency situations	
W	Roles and responsibilities within the operations team are clearly defined so that each individual knows their allocated tasks and responsibilities in normal and emergency situations.	
X	A structured approach has been used to identify the required team competencies.	
Y	There is a general job description for each member of the operations team.	
Z	There is no definition of team roles and responsibilities. There is no identification of core competencies.	

WILLINGNESS TO INITIATE MAJOR HAZARD RECOVERY (KNOWLEDGE AND SKILLS)

<u>Operators</u>

1. Do you have a feel for the costs associated with emergency action? *Yes (1st operator). Wouldn't consider costs in an emergency action, would just do it if needed for safety (2nd operator). Know that some customers need a minimum amount of notice before stopping their gas supply, otherwise they are liable for a several million pound fine (3rd operator)*

2. What are they in terms of downtime/£'s/start-up requirements *Financial. Knows that it a lot of money for shutdown because of the cost to the main customer (owned by the same company)*

3. How have you acquired this knowledge? (e.g. peers, briefings) *Peers, briefings. It is obvious from your training and you understand that our main customer depends on you and you are always running to export targets (know these are all cost driven from your training)*

4. Are you cautious about taking particular actions because of costs or because you are worried about criticism? *Sometimes (1st operator). No but make certain by double checking that the decision is right as know will be questioned afterwards (2nd operator)*

5. Do you think that the written procedures correctly reflect the cost of recovery actions or take them into account, please provide examples? *No (1st operator). Yes, not stated but is put across in training. Take export figures on an hourly basis (2nd operator)*

6. Do you think that your understanding of associated costs is the same as other operators, supervisors, senior management? *No. Senior management have more knowledge of costs as they are involved with them every day. Most phone calls to managers out of hours are around export targets and whether we really want to try to do particular ones. Therefore it is being cost driven by the operators e.g. if get less efficiency from liquid separation*

    a) Have their perceptions been communicated to you? How? *No (1st operator). Yes, it is a daily job requirement to be aware and actions* ***are*** *the business*

    b) Have you been able to test their perceptions, please provide examples? *Yes, have called managers over on situations and correct action has always been taken. One example, the manager said shut down the plant, the operator would have just shut down the unit*

    c) Were there any discrepancies in practice, please provide examples? *Yes (1st operator), no (2nd operator)*

7. Do you have environmental procedures which contradict certain recovery actions, please provide examples? *No*

8. Is it clear to you when the plant is safe or unsafe and recovery actions are required? *Yes, one operator made the point that most of them have several years experience at major hazard chemical sites and/or off shore prior to joining the company and were good quality people*

c) How? *From experience, DCS information, alarms, flaring, ESD status, F & G (?)*

d) Do you think it is the same for experienced and inexperienced operators, please provide examples? *No it is very complex, need 1-2 years experience before left alone on the panels. Making the right decisions is based on skills and knowledge and age (maturity)*

9. Could experienced operators disagree with inexperienced operators, please explain? *Yes and experienced with experienced. There is always more than one way to look at things. Is resolved by discussion of basis of decision and there are three people so it decided amongst the shift. There may be an historical reference, can always phone the duty call-out manager to help make a decision (but this is perceived as losing a bit)*

Example of how 2 experienced operators disagreed on action to take during a scenario:

A neighbouring site had a flammable gas leak and the fire brigade phoned the control room to request that they turned off heaters. The experienced operator he spoke to wanted to turn them off. The other experienced operator wanted to leave them on as they were at ~700ºC and it would take >24 hours for them to cool down so there was no point. The operator recounting the event was unsure how it was resolved but the heaters were not turned off and when the reason was explained to the fire brigade, they accepted the explanation and also that the heaters could not be cooled any other way.

10. Are you worried about being too cautious if you initiate recovery actions, please explain? *Always, unforeseen problems may occur (1st operator). No (2nd operator)*

11. Do you feel the need to ring somebody senior to yourself before initiating recovery actions? *Yes (1st operator). No not really, something we do to inform them of events (because money is involved). The commercial technicians are in touch with London who need to know. Managers have always backed up the operations team, even when they were not right.*

c) Do you have to? *Yes, it is procedural (1st operator); No (2nd operator)*

d) Do you feel more comfortable doing so? *Yes*

<u>Management</u>

1. Have you assessed the costs associated with recovery actions? (e.g. equipment, lost product, start-up resources) *Yes, are fortunate in that can shutdown in an hour and be back up in an hour. It is better to shutdown quickly rather than drag it out as it will impact ion the time it takes to get it back up. There was an incident a few years ago where the team did not shutdown the plant for 8 hours and filled the flares with liquid and got the plant in a mess, it could have deteriorated to a major incident. It took ~12 hours to get the plant back. There was a major review of the above incident and management made sure that the message was got across to shutdown quickly.*

2. Have you communicated this to operators? *Yes*

3. Are these taken into account when writing procedures? *Mainly refer to safety*
4. Are normal operating procedures checked to ensure there is no contradiction with recovery actions required in the event of a major hazard scenario?
5. How is the relative importance of safety compared to productivity/environmental performance communicated? How often does this happen?

<u>Documents</u>

1. Costs associated with recovery actions
2. Training records
3. *Operating procedures*

Ladder assessment

Grade	Description	Rationale
A	**The management is fully aware that recovery actions can be 'costly' and recognises that operators may be reluctant to enact recovery because of the costs. They give operators regular opportunities to test their willingness to initiate recovery actions in structured simulation or desk-top exercises.**	**Both the operations manager and the HSE advisor placed the control room here. The operations manager made the point that there is a very pro-active approach to shutting the plant down to limit danger plus it can prove beneficial to shut the plant down quickly as it is much easier to return it to service. If operators prevaricate before shutting down the plant's condition can deteriorate to the point where there is a long delay before it can be brought back on line.** **The actions required for different scenarios are run through in table-top exercises and off-site simulator training so that operators are clear when to take action.**
B	If recovery actions can be costly, the organisation is proactive in finding ways of reducing the costs, with operators being closely involved in these efforts.	The plant has been designed so that it can be rapidly shut down with minimal damage and brought back-up quickly with little impact. Operators can make suggestions to improve any aspect of plant performance, these are assessed and operators are involved in the implementation.
C	Operators are not fearful of reprimand if they wrongly initiate 'costly' recovery actions as long as they felt justified to do so.	The clear priority is to protect own plant as it has the major hazard. All operators interviewed were very clear on this and had no problem with the idea of taking the plant off line if they felt justified.
W	When plant performance targets are discussed and reviewed (such as environmental targets), a reminder is nearly always given that safety is paramount and must take priority when in doubt. This gives operators confidence their superiors fully understand the 'cost' of recovery actions.	
X	Reminders are seldom given to operators that safety must take priority when in doubt. Operators are given more frequent reminders of targets for production / quality / environment.	
Y	Although it is acknowledged that recovery actions, such as emergency shut-down, can result in significant damage, etc., there is a belief that operators will somehow find a way of shutting down without suffering losses. There is no rehearsal of scenarios to test such beliefs.	
Z	Recovery actions can result in significant loss of product, equipment damage, etc, but these 'costs' are not taken into account in the development or revision of emergency response procedures. Operators feel they alone appreciate the 'cost' of recovery actions. Operators feel their management either do not understand the 'costs', or avoid discussions about the 'costs'.	

MANAGEMENT OF OPERATING PROCEDURES (ORGANISATIONAL FACTORS)

<u>Operators</u>

1. Are you familiar with all or some procedures? *Yes, use procedures if need them and know where they are*
2. How often do you consult them, please give examples? *Only when required. When first started, used them quite a lot for training, have been here 3 years now and now only use them when necessary, only for unusual things which haven't done for a while.*
3. Were you trained using them, how were they used? *Sometimes, some modules incorporate procedures so use them as got through modules*
4. Do they reflect what you do, please explain? *Mostly, some didn't but they do now. Recently they have been revised for ISO9002. If look at one and see that it is out of date then will flag it up.*
5. Are they:
    a) Current? *Not all, currently being updated (1st operator) Ones looked at so far have been (2nd operator)*
    b) Correct? *Yes (1st operator) Ones looked at so far have been (2nd operator)*
    c) Understandable? *Yes (1st operator) Ones looked at so far have been (2nd operator)*
6. Who writes them? *Operators who have been pulled off shift, sometimes referring to equipment supplier instructions. Are reviewed by management*
7. When are they updated (e.g when a change occurs and/or after a specified time period)? *Annually or when a change occurs (1st operator). When notice they are out of date, there have been so many changes on Train 2 that procedures change every year. If the changes are on plant then normally the procedures are checked to see if they need changing but it can get overlooked (2nd operator)*
8. Who is responsible for controlling procedures? *Document controller (1st operator), operations manager and engineering and development manager (2nd operator)*
9. Are operators involved in procedure writing, please provide examples? *Yes*
10. Are procedures received by operators before they are approved and made formal, please explain process used? *Yes, when get new procedures they are put in the control room on the mailing list (plus e-mail) and you can make comments on them and send them back for modifying*

11. Are procedures provided for significant process changes, please provide examples? *Yes, just had one done for crossovers*

12. Are procedures audited to ensure that they are still current? *Yes, just gone through an audit recently*

Management

1. Who is responsible for managing/controlling operating procedures? *Operations manager/document controller*

2. Are procedures part of a site quality control system, please explain system? *Currently progressing towards ISO 9002. Historically, have been a culture driven rather than a procedure driven site but are trying to improve the procedural side(Operations manager). Started the progress towards ISO 9002 in June 2000 (Quality issues co-ordinator).*

3. How are procedures updated and out of date procedures recalled? *Procedure being developed for ISO 9002, want operators to update procedures when required and send back for revision. Want to try to encourage use-try to introduce a ticklist at the bottom and date when used, if they are not used then do they need to be there? (Quality co-ordinator). The mod form will trigger a review of procedures*

4. Who approves procedures? *Management, 3 people, final approval is the manager of that division or department such as the admin manager or maintenance manager (Quality co-ordinator)*

5. Are procedures audited and who does it? *Independent consultants audit maintenance and operations against best practice and consultant is changed every two years. Also audit from own company and will be done on a 3 yearly basis, will also do internal audits (people have gone on training courses) and also there will be an external auditor (don't know which company yet) every 6 months. Want to internally audit each area every 3 months by a team of people from anyone on site (all will be trained). Don't know the exact structure of it yet (Quality co-ordinator)*

6. Is the procedure QC system reviewed and improved, please explain how? *Will be part of ISO 9002. Are improving system now and reviewing every procedure. Some standing instructions have been replaced by procedures but some need to be kept. Standing instructions (also controlled) lie underneath the procedures to give more detail(Quality co-ordinator)*

Documents

1. *Operating procedures showing date issued, author, approver, version number*

2. *Quality manual detailing how procedures are managed*

3. Operating procedure audit results

Ladder assessment

Grade	Description	Rationale
A	**Information on best practice is pro-actively shared between production units and sites**	**Operations managers view of control room position. Is probably a reasonable assessment as the results of the external audit and the progress of the site towards ISO 9002 is communicated around the wider company**
B	The procedure quality control system is subject to review and continuous improvement.	Site has an external audit carried out annually by consultants (change consultant every 2 years) which compares it against industry best practice, any improvements identified are implemented. Plus the progression towards ISO 9002 is ongoing and the system will be continually reviewed and improved
C	There is a comprehensive procedure quality control system which the operations team is an integral part of and which ensures that procedures are recalled and updated when there is any process, equipment or staff change which necessitates it.	HSE advisors view of control room's position, does not take into account the external audit and its function to review and improve performance
D	The operations team are responsible for ensuring that procedures are up to date and reflect current best practice.	Yes, they indicate when a procedure is out of date and mark up changes required
E	Existing procedures are audited regularly to ensure they represent current best practice used by the operating teams.	Yes, plan is to audit procedures as part of ISO 9002 and operators will be part of the auditing team.
F	Operators are part of the procedure writing team and all operators are fully trained in new procedures and given the opportunity to provide feedback on the procedures before they are approved and made formal.	Yes, write procedures with engineers or managers. The procedures are circulated to whole operations team for the opportunity to comment
G	The procedures are accessed close to point of use and are presented in a clear, concise manner with checklists and other job aids for critical operations.	Yes, all within a cupboard within the control room. Checklists are contained (e.g. for trips) and identifies actions for identified roles i.e. control room operator and field operator for particular procedures
X	It is clear which procedure should be used for a particular task or situation. All information required for a particular task or operation is kept together and is easily referenced.	
Y	New procedures are provided for significant process changes. There is a quick run through given to operators when the procedures are introduced.	
Z	Procedures were written several years ago and there have been few if any changes. There is no evidence of procedure quality control system. Operators play no part in the writing. There is a quick run through of procedures given to operators when they are introduced.	

MANAGEMENT OF CHANGE (ORGANISATIONAL FACTORS)

Operators

1. Can you think of any examples where there was a significant change to process/procedures/people which affected CR operation, please describe? *Yes, taking on inexperienced operators, debottlenecking project. There are changes ongoing, the new crossover systems, new users coming on line.*
2. Were you aware of the planned change before it was introduced, how did you learn about it? *Yes*
3. Were you consulted /involved in planning the change, please explain? *No / yes, given a chance to air my views*
4. Was a transition phase used to ease the change, please describe? *Partially*
5. Was there a review after implementing the change, please describe? *No / yes, communications day*

Management

1. Are there guidelines or is there a policy for managing changes to process/procedures/people, please describe? *Yes*
2. How is organisational change managed (particularly changes in control room staff and control room support staff)? *Yes*
3. Where CR operation is affected, are CR operators involved? *Yes*
4. Are the safety implications assessed of proposed changes, please provide examples of where this occurred for:
    a) Equipment changes *Yes, HAZOP*
    b) Procedural changes
    c) Organisational changes?
5. Are there examples where proposed changes have been abandoned if it is found that safe CR operation is compromised, please describe? *Yes*
6. Are transition phases used, please describe?
7. Is there a review programme after change is implemented, please describe? *Not formally*

Documents

1. Procedures for managing equipment, procedural and organisational change
2. Organisational change policy document
3. Evidence of review after implementing change
4. Evidence of change (equipment and organisational) being risk assessed

Ladder assessment

Grade	Description	Rationale
A	**There is a review programme after change is implemented. The extent and number of review steps is dependent on the significance and scope of the change.**	**Operations Manager's view of control room position. Equipment and procedural changes are covered by the mod form procedure and HAZOP and Design Review.**
B	Where possible, transition phases are used to ease the change and ensure that safety is not compromised. If the transition phase shows the planned change is likely to compromise safety (through operator experiences, near misses, dangerous occurrences) the change is reversed.	HSE advisors view of control room position. Transition phases have been used for major plant changes and when new people are introduced to the control room they are supported by two experienced operators until they have achieved their five process modules
C	A gap analysis on skills is carried out and resources assigned for training prior to the change. The impact of the change on emergency response is assessed and included within the gap analysis and training programme	Yes is carried out for equipment and plant changes. Have not been any organisational changes, have been increasing the size of the operations team, from 20 to 23 to 28. Only require 20 for running and maintaining the plant, the rest are on projects
W	The key people affected by the change are identified by analysing the effects of the change and are consulted during the change management process and their views are respected.	
X	The decision to change is reversed if it is found that safe control room operation is compromised.	
Y	Any change is assessed for safety implications and the risks systematically assessed. The assessment team is selected based on skills and knowledge	
Z	Operators are not part of the change management team. There is no assessment of how safety may be affected by proposed changes and no transition phase to help manage the change. There is no review after the change to check its effectiveness.	

CONTINUOUS IMPROVEMENT OF SAFETY (ORGANISATIONAL FACTORS)

<u>Operators</u>

1. Is there a mechanism for suggesting improvements? *Yes*

    a) How are they raised/discussed/recorded, please describe process? *Mod form procedure, raise it, it is circulated around management, it is recorded in the mod form book. There are mod review meetings monthly or 3 monthly and actions come out of these.*

    b) Are they assessed and then implemented? *Yes*

    c) How are they assessed and then implemented? *Through mod form and HAZOP studies/Design Review by managers and engineers*

2. Are operators involved in reviewing incidents, please provide examples? *Yes, fill in incident report form initially. Do safety away days, one every 6-12 months. Review main incidents and lessons. Investigation and implementation of improvements is by the management team*

3. What type of incident is reviewed (e.g. major incident, minor incident, dangerous occurrences, near misses)? *Process, equipment, procedure incidents, all-pump failures, permit issues. During shutdown had a pipe break-in when shouldn't have been done. It was reviewed and talked through by the management team and the people involved.*

    a) How is it done, please describe process? *Incident investigation and event report*

    b) Are the results fed back to you, please explain how? *Yes, see actions that come out of reviews. Only people involved in the incident get detailed feedback, thinks it should be sent to everyone*

4. Is CR operation reviewed against safety performance measures, please explain how? *Yes*

    a) Are operators involved? *Yes, there is a safety incentive scheme which is based on the number of incidents*

    b) How is it done? *Through safety audits and meetings*

    c) Is product quality reviewed for indications of operational problems, please provide examples? *Yes (1st operator). No, not product quality, we review ongoing process relying on instruments. A chromatograph is produced for sample taken twice a week and get the results back and file them, would like to be able to make more use of information, make notes of main components and use to monitor variables (2nd operator)*

5. Do you consider incidents reported from other plants and incorporate lessons learned, please provide examples? *Yes, personally from time in previous company. Also the tabletops look at other people's problems and whether they could happen here and what we can do to prevent them.*

<u>Management</u>

1. Is there a policy of continuous improvement which incorporates CR safety, please describe? *Yes*

2. Who is responsible? *Site Director*

3. Who is involved? *All site staff*

4. How are improvements suggested, assessed, implemented? *Mod form*

5. What type of incident is reviewed (e.g. major incident, minor incident, dangerous occurrences, near misses)?

   a) Who does it?

   b) How? *Monthly event review meetings for managers and engineers, the actions generated feed into the monthly HSE meeting where further actions may be generated. Safety away days every 6 months. The challenge is getting operators to attend the meetings as do not read e-mails for weeks etc. Communications are a constant battle, use several forums but then can be criticised for having too many modes of communications.*

   c) What is done with the output? *Actions generated*

6. Is CR operation reviewed against safety performance targets?

   f) Who does it?

   g) How do they carry out the review? *Business plan sets targets and performance is reviewed against these*

   h) Is product quality used as an indicator, please explain how it is used? *No*

   i) Are other plants used for learning opportunities, please provide examples? *Yes e.g Pembroke, Longford. Spent ~£20k on lessons learnt from Pembroke (very similar plant), helicopter screen was one improvement, there is a very large file on the study. Are reviewing Longford at the moment. Have put an incident board etc in from lessons learnt from past incidents.*

   j) Do you share your learning with others, please provide examples? *Try to*

Documents

1. *Site safety policy*
2. *Safety statistics (no lost day accidents in 7 years)*
3. *Incentive scheme details*
4. Graphs displayed on noticeboards
5. Output from continuous improvement initiatives
6. Company wide literature with safety information included (safety improvement initiatives and safety performance figures)

Ladder assessment

Grade	Description	Rationale
A	The organisation is proactive in sharing its learning with others.	Does not share lessons learned outside the organisation
B	Incidents reported from other plants, particularly plants with similar processes and control room arrangements, are screened for possible lessons. Learning opportunities are then explored and identified in a structured manner.	Have carried out in depth analyses on incidents which have occurred in similar plants within the industry, identified lessons which can be applied on site and the improvements implemented.
C	All aspects of control room operations are reviewed periodically and constructively with the involvement of operators. The review is not restricted to incidents/near misses but includes a review of parameters, such as product quality, that could indicate operational problems.	Is integrated into monthly Health and Safety meeting
D	When changes are made in control room operations they are reviewed after three to six months.	No
E	**Investigations from incidents / abnormal events are used in the review of training needs and operating procedures.**	**Operation manager and HSE advisor's view of control room position as they do not review changes after 3-6 months although it does satisfy the two rungs above.**
V	The lessons from incidents / abnormal events are formally briefed to all operators and they are given an opportunity to comment on the analysis.	See below
W	Incidents and abnormal process events are analysed, with the immediate and root causes identified. Operators are involved in the analysis. How the incident could have developed or could have been responded to under different process or operational conditions is considered explored. Lessons specific to the scenario and general to other conditions are drawn out.	There is a monthly incident investigation meeting which feeds actions into the monthly Health and Safety meeting which the whole site is invited to. There are Safety Away Days, communication meetings and HSE meetings to try to ensure that every operator has an opportunity to participate.
X	Formal guidance is given on what type of incidents / abnormal events qualify for investigation.	
Y	Unusual or severe incidents and near misses that are not thought to have happened before are reviewed. The circumstances are recorded and a limited analysis is undertaken. Operators are told the results of the investigation, perhaps in the form of briefing / memo/ instruction.	
Z	Operators are relied on to raise problems and make suggestions for improvements. Issues are discussed informally between operators and their immediate management / supervisors. Comments are noted in the shift log or equivalent at the discretion of operators.	

MANAGEMENT OF SAFETY (ORGANISATIONAL FACTORS)

Operators

1. Are you familiar with site safety policy and performance, please describe? *Yes*
2. How has it been communicated to you?
   a) Training? *Yes*
   b) Briefing? *Yes*
   c) Safety committee? *Yes and monthly meeting. It is an open meeting and everyone can and does contribute. It is chaired by an operator usually, sometimes somebody else chairs. Go through results of safety audits, Permits to Work checks, incident reviews. It lasts approx. 2 hours.*
   d) Noticeboard? *No*
   e) Other? Please define *HSE monthly report which gives all the incident and injury statistics and information. Get RoSPA magazine*
3. Are you involved in:
   a) Safety committee? *Yes, HSE meeting*
   b) Incident investigation? *Sometimes*
   c) Writing safe operating procedures? *Yes*
   d) Safety auditing? *Yes, check area once a month, 1 operator is involved each time*
   e) Improving your area's safety performance? *Yes through site safety meeting, plus things that you see, comment on and let people know*
   f) Other? Please define
4. Are you aware of safety initiatives in other production areas or sites, please describe? *Yes, know of initiatives at other sites he's worked at. Do not really find out about other company sites and how they perform but can find out directly.*

Management

1. Who is responsible for managing site safety policy? *Operations manager, development and engineering manager*
2. How do you apply it?
    a) Safety committee? *HSE monthly meeting*
    b) Auditing? *Yes*
    c) Continuous improvement in areas? *Monthly review meetings*
    d) Performance targets? Yes
    e) Compare performance with other units, sites? No
    f) Other? Please define
3. Who is involved? *Management/engineering/operators*
4. Do you encourage site employees to experience other sites' methods of working, please provide examples? *No*
5. How do you benefit from this? *N/A*
6. How is the production area and site performance communicated to employees on site and across sites? *Monthly report*
7. Do you share your learning and safety management methods with others, please explain how? *No*
8. Is safety integrated with quality and environmental management systems, please explain how? *Yes*

Documents

1. *Site safety policy*
2. Audit reports, action plans
3. Performance monitoring graphs
4. Evidence of safety management system

5. Safety committee minutes
6. Continuous improvement team output
7. Company wide literature with safety information included (safety improvement initiatives and safety performance figures)

Ladder assessment

Grade	Description	Rationale
A	The organisation is proactive in sharing its learning and safety management methods with others.	Not company policy
B	**Operators participate in continuous improvement teams which tackle safety as well as quality and environmental improvement. Any ideas the teams have can be implemented based on costs and benefits. Results of changes are reviewed and communicated to other area teams.**	**Operation Manager's and HSE advisors view of the control room's position. All operators have improvement projects as part of their annual objectives and are expected to generate ideas for new improvements and they can be in any area. They are systematically assessed and if approved, implemented.**
C	The organisation has a clearly defined safety policy across all sites and clear targets for sites to aim for. Site and company safety performance is communicated across all sites via company literature and improvement ideas transferred. Site employees are encouraged to experience other sites methods of working to standardise sites and share improvement ideas.	Yes, it is clearly defined and communicated clearly to all employees through training, away days, HSE meetings. Operators are aware of any former employer safety initiatives. Events on other sites within the company and within the industry are used as learning material.
D	The site has an integrated safety policy with safety performance monitored in each site area, results and trends communicated to the entire site and improvement targets set.	Yes, part of business plan. Target is to maintain record of zero lost day accidents since start-up. All incidents including pump failure are analysed for lessons to learn and opportunities for improvement
E	Site safety audits are regularly carried out, operators form part of the auditing team and participate in analysing and reviewing the results and drawing up action plans.	Yes, weekly, an operator involved each time
F	The site safety committee investigate issues brought to the meeting, assigns actions and then tracks actions at subsequent meetings.	On-site HSE monthly meetings are used for this plus safety away days where go through incidents off-site.
W	Site safety audits are regularly carried out. Operators are not included on the auditing team. Results are communicated back via the operators' immediate management/supervisors.	
X	Safety performance targets are written into individual job objectives for CR supervisors and managers	
Y	The site has a safety committee for which operators have a representative(s). The representative can take any issues from the operating team to the safety committee for discussion. Outcomes from the meeting are communicated informally via the safety representatives.	
Z	Operators are not directly involved in site safety policy and are not included in incident investigation, safety committees or establishing safe operating procedures. There is no communication of site or area safety performance. Any involvement is informal and takes the form of verbal communication.	

Table 2 Summary of ladder assessment for Site 1

Element	A	B	C	D	E	F	G	V	W	X	Y	Z	Action
Situational awareness													
Teamworking													An explicit method for assessing the effect of operating staff changes on the control room's ability to recover to a safe state would progress the control room up to the top rung
Alertness & fatigue (work pattern)													
Alertness & fatigue (health)													Evidence of a health monitoring programme being used to monitor for signs of long term fatigue and its use when reviewing controls on medication would progress the site to the top of this ladder. Occupational health medication controls and monitoring for signs of fatigue, worthwhile ensuring there are controls in place (it was not possible to check the details of the existing arrangement with occupational health during the study).
Training & development													
Roles & responsibilities													Although the plant has a high assessed position on the ladder, operators expressed concern about there not being a clear person in charge (e.g. shift supervisor) in the situation of a major incident and that they may be open to criticism by HSE if there were problems. They did not feel they wanted or needed a supervisor but had a particular concern in this situation. According to the site Incident Control Plan, it should be clear who takes control as for a shift team of three the Lead Operator should be identified and he would take control of the incident until the Operations Manager arrived. The operators interviewed felt that whoever was on the console would control the incident and it could be any of the three. Perhaps they need the issue clarifying as they were worried about the potential perceived lack of clear leadership; particularly as the operator who happened to be on the console at the time may not be a 17 module or even a 9 module operator and may feel it is unfair for him to be expected to take that level of responsibility and may be concerned about the other two operators not supporting him in questions afterwards.
Willingness													
Management of operating procedures													

Element	A	B	C	D	E	F	G	V	W	X	Y	Z	Action
Management of change													Policy for organisational change, not clear that they have one and what controls are explicitly in place, good for equipment and procedural changes. The module system and requirements for balanced experience in every shift team are implicit controls, could benefit from making explicit that these act as controls for ensuring safety is not compromised during staffing changes. Potential to improve the review of changes (equipment, procedures, organisation, safety improvements).
Continuous improvement of safety													Site satisfies rungs C (CR and field operation is reviewed as part of the monthly Health and Safety meetings) and B on the ladder as in depth analyses are carried out on incidents which have occurred in similar plants within the industry, lessons identified which can be applied on site and the improvements implemented. To progress to B, there needs to be evidence of review after changes to CR and field operation (to satisfy rung D). Operators would like to have access to the detailed results of all incidents analysed not just the ones they are directly involved in.
Management of safety													The organisation policy is not to share its learning and safety management methods with others which is the requirement for rung A on this ladder.

Therefore the site operation was assessed as acceptable in all ladder elements, however the actions identified in Table 2 could be used to progress the plant further up the ladders of:

- Teamworking.
- Alertness and fatigue (work pattern).
- Alertness and fatigue (health).
- Continuous improvement of safety.
- Management of safety.

Some examples of good practice are summarised below plus some concerns raised by the site during the assessment.

Examples of good practice

- **Training and development, roles and responsibilities:** Modules provide a clear framework for a multi-skilled operations team with the potential for specialisation. It also allows the shift teams to be balanced in terms of experience.
- **Fatigue (workload), situational awareness:** Shift system, there are no fixed teams instead they act as one big team with no supervisor, high autonomy, high degree of delegation to the three operators on shift The operators get a long rest but get to work on maintenance on days for four weeks to become re-familiarised with the plant before going into a block of operational shifts. There are additional operators for project work and therefore this frees operators for training. The plant administrator manages the shift system ensuring that no work pattern controls are infringed and acting on operator feedback for situations which cause fatigue plus she ensures that each shift team is balanced in experience and have sufficient experience for night or weekend work. The use of annualised hours controls overtime and having an extra 8 operator technicians working on projects minimises the need for overtime.
- **Training and development, continuous improvement of safety, management of safety:** HSE training, tabletops, simulator training, away days, process training. Learning from incidents, own and similar processes. Improvement scheme. HSE communications, site monthly meeting

Other concerns raised by the site

Trying to simulate scenarios which have the kind of unexpected events which may happen in practice to test the decision making skills of the operations team e.g flammable gas cloud is coming towards the site, the control room is asked to turn the flare off but the Operations Manager believes it is not a safe thing to do when there are hydrocarbons on site. The best course of action is to sit and monitor the wind direction and hope that the flare does not ignite the gas but it is a very difficult position to put an operator in as it is a very difficult decision.

Multiple alarms from the DCS is the one issue arising from the Pembroke study which they have not been able to tackle sufficiently. Operators put mod sheets in for additional alarms because they missed an alarm once and got close to the trip point so can end up with 2 / 3 alarms before you get to a trip point. The number of alarms quickly escalates as each vessel has 3 hi level and 3 lo level alarms and it will be complex, large and expensive to sort out. No-one consulted has come up with a practical solution.

Issues raised about the assessment method

Physical assessment: Scenario specification, number, type, definition, how to be able to assess time available. How to help with visualisation of scenario prior to and during assessment. The scenarios covered in this case study were not defined sufficiently to be able to visualise the situation and the actions that would be taken. They needed better defining in terms of scale (between process upset and off-site plan required) and also in terms of technical detail (e.g. location, leakage rate, wind direction etc). Therefore need to define what type of scenarios need to assess (as do not want too much repetition but need to ensure cover worst case situations) and the level of detail required. Main aim of second site case studies is to understand this requirement and gain a definition.

Ladder assessment: Make questions more open, encourage the use of examples that can be referred to as evidence. Check progression of ladders and their applicability across industry. The ladders used during the case study were slightly different than those used to present the results due to consultation with the HSE and the case study sites. However it has been possible to use the information collated during the case study to complete the ladder.

The different responses to questions and ladder positions confirms the need for a team approach to assessment of ladder elements so that a consensus can be achieved, followed by peer review so that the assessment outcome is owned by all people affected.

APPENDIX D

Case study 2 summary

Case study 2

Site introduction

The site has operated since the 1930's although the plant and processes have been changed and upgraded and there have been several changes of ownership. There are several control rooms and operating units on site and approximately 500 people on site in total. Two ooperating areas were assessed, one comprises a single batch operated unit, the other comprises two continuous process units.

The site has been going through major equipment and organisational changes over the past 18 months and are currently part way through these programmes.

The major hazard for the site is toxic gas release, there are large quantities of two toxic gases on site.

As with the first case study site it is surrounded by other major hazard sites and so has to be able to deal with an emergency which is caused by an off site event.

Operating area introduction (batch)

The control room monitors a batch dilution process. The control has been upgraded within the past 12 months to DCS, there are now level trips on all tanks, there are emergency stops on the plant but there is not one in the control room yet. The E-stop stops the main pump and recirculation pump which maintain flow of the hazardous liquid. Isolation valves have to be operated on the plant, there are no automated isolation valves.

There is one operator on shift to monitor variables in the control room and operate the process on plant. This operator is also responsible for loading tankers a few minutes up the road. He can hear process alarms anywhere on the plant and when loading a tanker. There is a shift supervisor who works from 8am to 4pm. The operations team for this unit are also responsible for the utilities plant which is about 5 minutes away. This unit has one operator present on shift and the same daytime supervisor is responsible for both units.

There is a team of ten operators who rotate around a five week shift cycle covering the batch chemical stores plant and the utilities plant. The shift pattern is summarised in Table 1.

Table 1 Summary of shift cycle for an operator

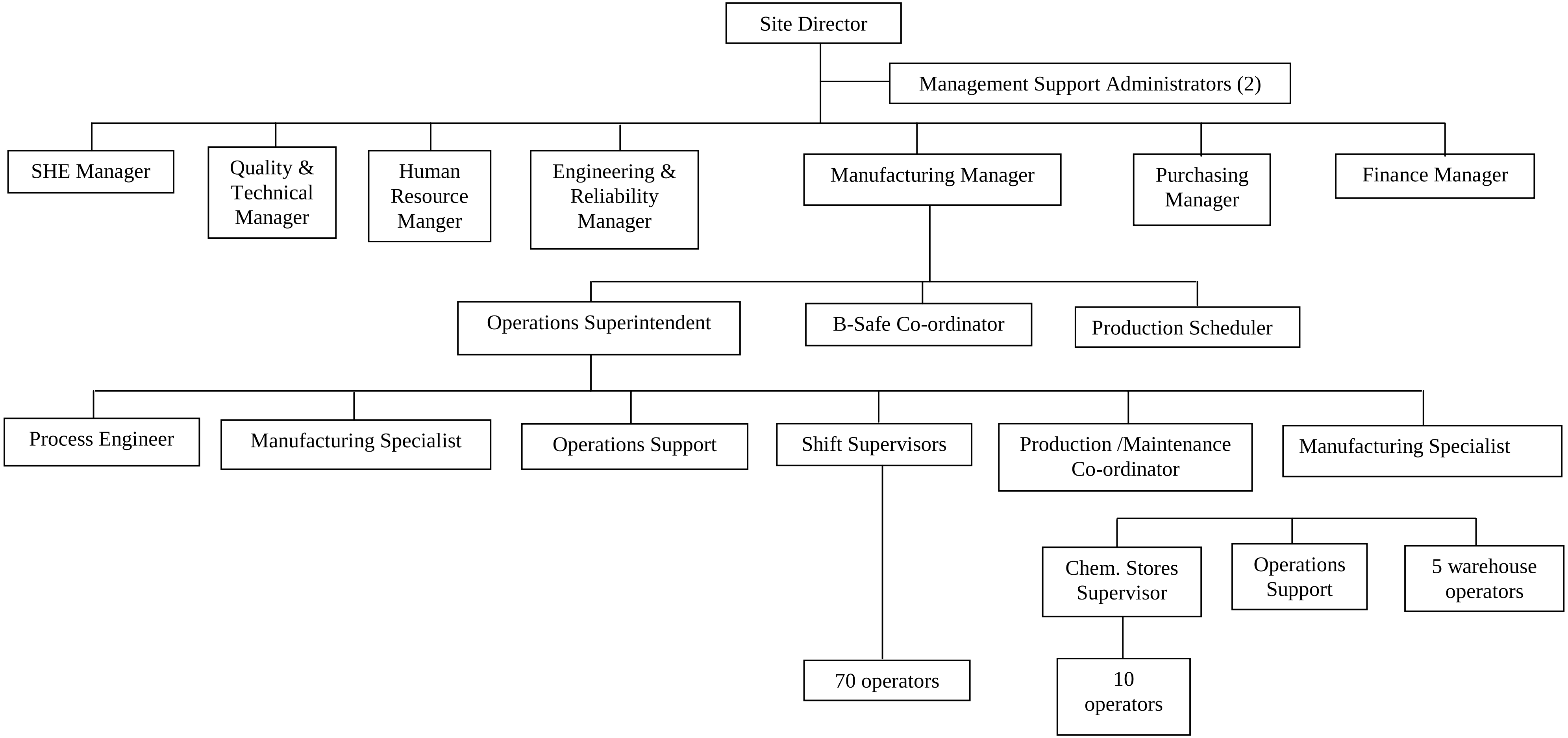
Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
				Morning	Morning	Morning
Afternoon	Afternoon	Night	Night			
Morning	Morning	Afternoon	Afternoon	Night	Night	Night
		Morning	Morning	Afternoon	Afternoon	Afternoon
Night	Night					

However the operators work many 12 hour shifts to cover sickness and holidays. There has been a trainee in this plant area for the past three months and that has required everyone to work 12 hour shifts in order to cover the shifts.

Site organisational structure

Figure 1 summarises the site's organisational structure down to executive level and then for the area of manufacturing where the chemical stores sits.

Figure 1: Site 2 Organisational Structure



Individuals involved in case study

During the case study the following people participated through interview or completing parts of the method themselves:

- 1 operator (It was not possible to talk to more than one as he was on 12 hour days for the four days of the study);
- area supervisor;
- human resources advisor;
- SHE advisor;
- system and procedures co-ordinator;
- occupational health supervisor.

The area supervisor and SHE advisor were given copies of the ladder assessment questions to make notes on and copies of the ladders to place the operating area on. The other people were interviewed on the ladder questions and the plant operator went through the physical assessment method for identified scenarios.

Assessment results

The physical assessment was done for two scenarios within this operating area and the results are summarised in Table 2. Both scenarios had occurred on site within the past 2 years, therefore incident reports were available plus the incidents were familiar to the operator interviewed.

Table 2 Summary table for Site 2, batch control room physical assessment

Scenario #	Scenario Description	PASS	Fail	Physical assessment #('s) failed on	Actions required
1	Flange leak of toxic gas, wind direction towards the road, at night		√	1, 2, 6	Steps 1 & 2: Implement man down alarm which contacts security if two audible alarms are not acknowledged by the operator after 15 seconds and 30 seconds, respectively (identified by area HAZOP). Need to ensure that failure rate of the man down alarm is as low as reasonably practical and of a similar order to safety critical plant items. (Otherwise need to consider other options). Additionally assess costs/benefits of cameras to assist plant monitoring Additionally the costs and benefits of having a mimic of the chemical stores DCS screens in a nearby continuously manned control room could be assessed. Step 6: Implement E-stop in control room (identified by area HAZOP). Additionally, assess costs/benefits of automated isolation valves plus assess costs/benefits of cameras to assist plant monitoring
2	Damage to plastic pipe, toxic chemical dilution by contractor (on days)		√	6	Step 6: Implement E-stop in control room (identified by area HAZOP). Additionally, assess costs/benefits of automated isolation valves plus assess costs/benefits of cameras to assist plant monitoring Plus additional steps to ensure that contractors report incident to security if the operator is not in the CR, by placing a notice in the CR and incorporating as a question in the weekly audits of contractors working on site

Therefore several areas of unacceptable risk were identified from the physical assessment and some suggested improvement actions identified by discussion with the operator and SHE advisor. The problems arise due to the plant having a single operator for control room and plant operations. The suggested improvements above are technology based, an alternative is to make other operator(s) available for plant work. To ensure that an outside plant operator was always available to the chemical stores and that the chemical stores control room was continuously manned, there would need to be a dedicated outside operator to the area which may mean that the utility stores would need a dedicated outside plant operator.

Table 3 summarises case study 2's performance on the ladder assessment elements and suggests improvement actions.

Table 3 Summary of ladder assessment for Site 2's batch control room

Element	A	B	C	D	E	F	G	V	W	X	Y	Z	Action
Situational awareness													Evidence suggests that it is currently quite difficult for an operator to keep track of process conditions during upset or emergency conditions as they have to personally detect a toxic gas leak as there is only one person who could be in the CR, on plant or loading tankers. The actions suggested in the physical assessment apply to this element
Teamworking													There is a plan in place for the operator to ask for assistance from an operator on the utility plant (if he is available) or to call in the next operator due in. Therefore the exact reasons and scenarios where the operator needs this assistance need identifying and assessing to ensure this arrangement does not introduce unacceptable risk to plant operation
Alertness & fatigue (work pattern)													Although the 'man down' alarm, a suggested action for the physical assessment will alert security if the operator is incapacitated, there is currently no contact between the operator and other personnel on site outside daytime hours. There are several people on site at all times, including a shift supervisor for the main production units. The lone operator is likely to benefit from some interaction with others during a shift to combat fatigue. Assess benefits of introducing interaction with other parts of the site outside normal hours.
Alertness & fatigue (health)													Could introduce review and improvement of health monitoring control
Training & development													New and existing operators would benefit from tabletop exercises on major scenarios. The site would like to do this but have a problem because the current shift system does not allow flexibility for people to be available for training and assessment. A structured training and development plan for each operator is suggested. There are plans for introducing a skill step system as part of a site re-organisation which will incorporate these aspects but this again depends on a change in shift system. Optional shift systems have been assessed but the changes need agreeing with the Unions
Roles & responsibilities													Key requirement is a management control which ensures that core competencies required for the operations team are retained during any staff changes. Plus the need for operator training and development plans are the main actions required to progress up this ladder
Willingness													A peer review of this ladder would be beneficial to ensure all agree about not being fearful of reprimand if they wrongly initiate recovery actions as long as they felt justified in doing so. The progression up this ladder requires the operators being involved in finding ways to reduce the costs of recovery actions which may not be applicable in this operating area as it does not really have costs associated with shutdown.

Element	A	B	C	D	E	F	G	V	W	X	Y	Z	Action
Management of operating procedures													There are plans in place for the procedures to be audited and for a new management of change system which ensures procedures are kept updated and out of date procedures recalled. It is also planned for the procedure control system to be reviewed and continuously improved. When these are implemented the operating area will progress up this ladder. It may be beneficial to tell people when new operating procedures are put onto the system as the site already does for new quality and SHE documents.
Management of change													The introduction of a review programme for changes would take the operating area up to the top of this ladder
Continuous improvement of safety													Key requirement is for the investigations from incidents/events to be used in the review of training needs and operating procedures. This can be done in conjunction with the improvements to the training and development element. This again requires on the operators being available for participation in training activities which the current shift system makes difficult. Additional improvements should be planned after this has been achieved
Management of safety													Operator involvement in continuous improvement teams which tackle quality, environmental and safety issues would progress the operating area up this ladder.

Therefore the first priority actions are those required to allow the operating area to pass the physical assessment. The next priority actions are those which will move the area to the left of the acceptable line in Table 3, in the areas of:

- Situational awareness (should be improved by actions required by the physical assessment).
- Teamworking.
- Alertness and fatigue (work pattern).
- Training and development.
- Roles and responsibilities.
- Continuous improvement of safety.

The third priority are actions which will move the control room further up the ladders listed above plus the remaining elements of:

- Alertness and fatigue (health).
- Willingness.
- Management of operating procedures.
- Management of change.
- Management of safety.

A comment which was made by the site during the case study was that the control room had progressed approximately 2-3 rungs in the past 18 months due to the changes already made to control room operation plus areas such as management of operating procedures. Therefore the control room is in a transition phase and there are plans in place which should progress the control room up most of the ladder elements. The proposed changes to the shift system and the introduction of structured progressive skillsteps will be introduced as a package and these measures will improve the control room's position on alertness and fatigue (work pattern), training and development and roles and responsibilities.

Issues raised about the assessment method

Physical assessment: Progress was made on the specification of scenarios in terms of the number, type and level of detailed description required i.e. the need to identify scenarios which could result in incidents with major hazard potential. There should be no fixed rule on the number of scenarios that should or must be analysed - each plant or unit is different. It is recommended that scenarios representing the following are analysed:

- Worst case scenarios requiring implementation of the off-site emergency plan;
- Incidents which could escalate without intervention to contain the problem on site;
- Lesser incidents requiring action to prevent the process becoming unsafe.

A site will also need to consider whether it is necessary to assess the scenarios at different times such as during the day and at night, during the week and at weekends, if staffing arrangements vary over these times.

It is necessary to define the circumstances of each scenario in sufficient detail. As a minimum:

- Define who is controlling the process and their starting locations;
- Define who is available to support the incident, and their starting locations:

- Define the parameters that determine the time available to the operations team for detection, diagnosis and recovery. Therefore parameters such as process conditions, leak point, wind direction, release rate, time of day, may need to be defined.

Sites should gather any historical data that is relevant to the detection, diagnosis and response to the selected scenarios.

Ladder assessment: The ladders used during the case study were slightly different from those used to present the results due to consultation with the HSE and the case study sites. However it has been possible to use the information collated during the case study to complete the ladder. The need for an introduction to each ladder element to explain the approach and key issues being explored was confirmed during this case study.

As seen in Case Study 1 the different responses to questions and ladder positions confirmed the need for a team approach to assessment of ladder elements so that a consensus can be achieved, followed by peer review so that the assessment outcome is owned by all people affected.

Additionally the study highlighted the need to provide guidance which advised people to place the operating area on the rung which represents the current situation not the future.

APPENDIX E

Case study 3 summary

Case study 3

Site introduction

The site is the same as case study 2 so has operated since the 1930's although the plant and processes have been changed and upgraded and there have been several changes of ownership. There are several control rooms and operating units on site and approximately 500 people on site in total. Two operating areas were assessed, one comprises single batch operated unit (see case study 2), the other comprises two continuous process units.

The site has been going through major equipment and organisational changes over the past 18 months and are currently part way through these programmes.

The major hazard for the site is toxic gas release, there are large quantities of two toxic gases on site.

As with the first case study site it is surrounded by other major hazard sites and so has to be able to deal with an emergency which is caused by an off site event.

Operating area introduction (continuous)

The control room monitors two continuous process units which involve several inorganic chemical reactions. The control has been upgraded within the past 18 months to full DCS with remote operation of plant equipment and adjustment of set points.

There is one operator on shift to monitor and adjust variables in the control room and communicate with field operators who patrol the plant and assist in problem diagnosis and recovery. The control room operator (CRO) only works in the control room although all existing CRO's have been field operators in the past. Each shift team has a shift manager who has an office adjacent to the control room, within the same building and who has read only access to the DCS. There are two senior operators on each shift team and 2 plant operators. Senior operators are used as relief operators for the CRO and assist in problem solving either in the control room or outside on plant. Senior operators also issue work permits (away from the control room), work permits are raised in advance as much as possible to allow work to be planned in. Each shift team has a senior operator responsible for each of the two continuous units, although they do overlap. Plant operators carry out patrols, stay with their plant unit and assist the senior operators as required. The shift team is not involved in plant maintenance.

For the two continuous manufacturing units there is an operations team of thirty who rotate around a five week shift cycle. The shift pattern is the same as the batch process and is summarised in Table 1. The team work 8 hour shifts which are:

- Morning: 8:00 to 16:00
- Afternoon: 16:00 to 0:00
- Night: 0:00 to 08:00

However the operators work many 12 hour shifts to cover sickness and holidays.

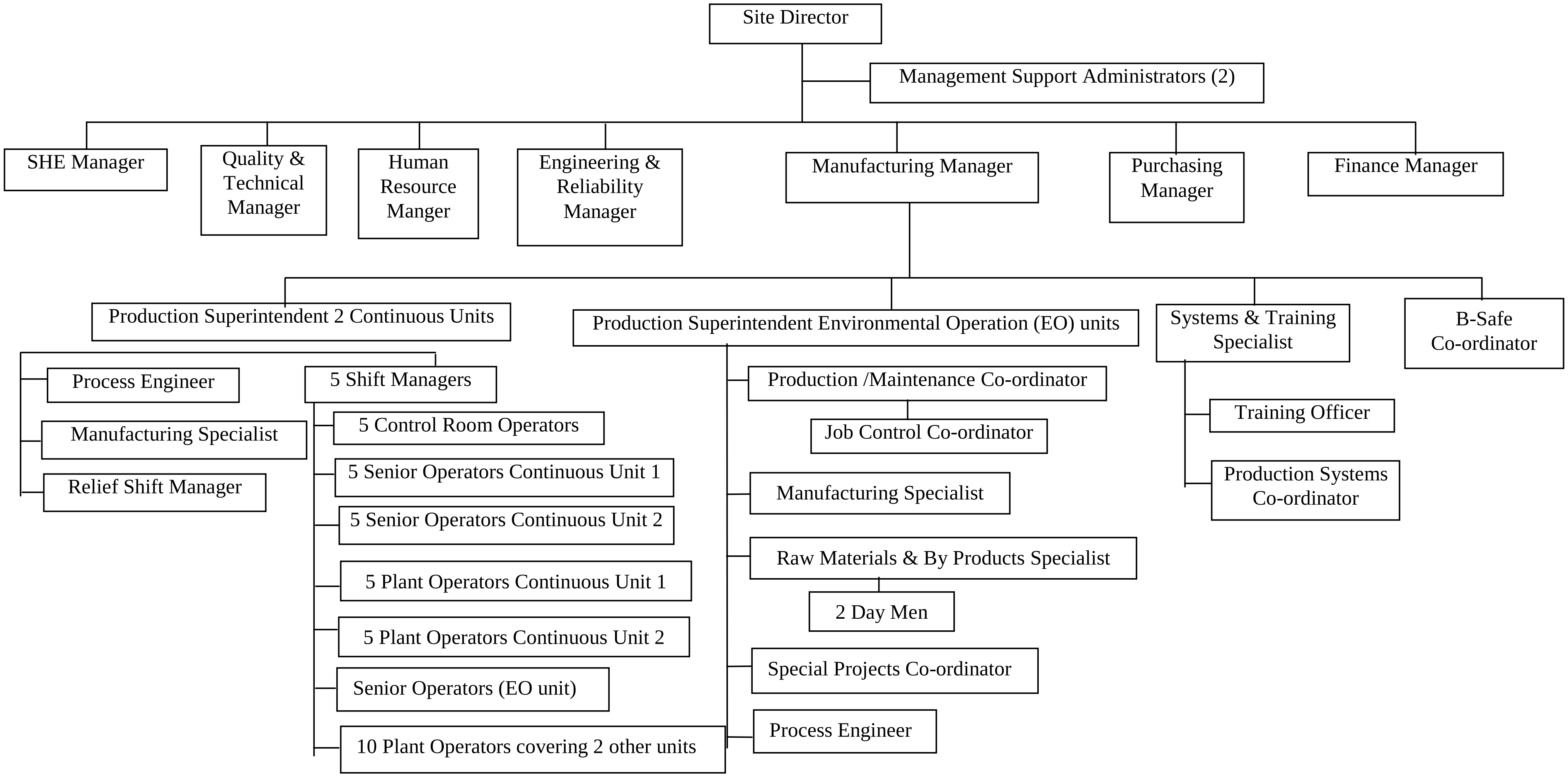
Table 1 Summary of shift cycle

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
				Morning	Morning	Morning
Afternoon	Afternoon	Night	Night			
Morning	Morning	Afternoon	Afternoon	Night	Night	Night
		Morning	Morning	Afternoon	Afternoon	Afternoon
Night	Night					

Site organisational structure

Figure 1 summarises the site's organisational structure down to executive level and then for the area of manufacturing where the two continuous units sit.

Figure 1: Site 2 Organisational Structure



Individuals involved in case study

During the case study the following people participated through interview or completing parts of the method themselves:

- 3 control room operator s (2 experienced and 1 trainee); (one operator provided the bulk of the information as he was on 12 hour days for the four days of the study);
- 1 shift manager;
- human resources advisor;
- SHE advisor;
- system and procedures co-ordinator;
- occupational health supervisor.

The SHE advisor was given a copy of the ladder assessment questions to make notes on and a copy of the ladders to place the operating area on. The other people were interviewed on the ladder questions and the plant operators went through the physical assessment method for identified scenarios.

Assessment results

The physical assessment was done for five scenarios within this control room and the results are summarised in Table 2. Four out of the five scenarios had occurred on site within the past 2 years, therefore incident reports were available plus the incidents were familiar to the operator interviewed.

Table 2 Summary table for Case study 3 physical assessment

Scenario #	Scenario Description	Pass	Fail	Physical assessment #('s) failed on	Actions required
1	All control room screens go blank on days	√			A question for the procedure in this scenario is whether the decision to shut down should be discussed or whether the CRO should go straight into shutdown. Another area to check was whether the gatehouse announcement system was independent of the control room based tannoy system. There is a procedure and it is possible to shut the plant down without screens. However the SHE advisor and the CRO interviewed were unaware of the plant having been shutdown without screens. Therefore this indicates the need for training and preferably opportunities for table-top practice of this scenario for both CRO's and field operators who would have to monitor plant status in the sub station.
2	All control room screens go blank on days	√			As above
3	Small toxic gas leak with no obvious screen indication (relies on 3rd party detection) on days	√			Steps 2 & 3: Additionally assess costs/benefits of additional cameras to assist plant monitoring (there are 4 already). There are four plant operators outside on plant (2 for the 2 units in the operating area assessed) plus 2 senior operators who spend time outside. However additional detection might be beneficial particularly when considering the same scenario at night Need to assess the maximum time it would take for the unit patrol operator to detect a leak on his unit and decide whether it is acceptable.
4	Small toxic gas leak with no obvious screen indication (relies on 3rd party detection) on nights	√			Need for additional detection stronger on nights as there is only the shift team to detect a leak. During the day there are numerous day time personnel moving around the plant who could detect a leak. Need to assess the maximum time it would take for the unit patrol operator to detect a leak on his unit and decide whether it is acceptable and whether additional cameras would be beneficial.
5	Toxic gas leak picked up by gas detectors	√			None

Therefore although no areas of unacceptable risk were identified during the physical assessment, some issues were raised and suggested improvement actions are given above which were developed through discussions with the CRO and SHE advisor.

Table 3 summarise the case study 3's performance on the ladder assessment elements and suggests improvement actions..

Table 3 Summary of ladder assessment for Case study 3

Element	A	B	C	D	E	F	G	V	W	X	Y	Z	Action
Situational awareness													The actions suggested in the physical assessment apply to this element. Testing scenarios would increase confidence in the ability of the operations team to reliably deal with upset and emergency conditions and ensure that each shift team performed satisfactorily.
Teamworking													The control room could move up to D on this ladder by providing a control which ensured that at least one person out of the shift manager and senior operators was always within the control room building to be available to quickly assist the CRO. The control room satisfies rung B as past incidents have proven that the operations shift team can recover the plant to a safe state. It was unclear from evidence collected whether there was mechanical, electrical and instrumentation expertise available on a shift basis. If there is then the control room would satisfy rung C and introducing the control on having at least a senior operator or shift manager within the control building would move the control room up to rung B.
Alertness & fatigue (work pattern)													There was no evidence of flexibility in the rostering system to allow additional rest days after periods of exceptional workload. This could be considered as a requirement of the planned new shift system.
Alertness & fatigue (health)													Could introduce review and improvement of health monitoring control
Training & development													New and existing operators would benefit from tabletop exercises on major scenarios. The site would like to do this but have a problem because the current shift system does not allow flexibility for people to be available for training and assessment. Trainee CRO's reported that they felt they were being 'played off' each other which they did not like plus it was felt by trainees and trainers that the training material should be updated to reflect changes. A structured training and development plan for each operator is suggested. There are plans for introducing a skill step system as part of a site re-organisation which will incorporate these aspects but this again depends on a change in shift system. Optional shift systems have been assessed but the changes need agreeing with the Unions
Roles & responsibilities													Key requirement is a management control which ensures that core competencies required for the operations team are retained during any staff changes. Plus the need for operator training and development plans are the main actions required to progress up this ladder

Element	A	B	C	D	E	F	G	V	W	X	Y	Z	Action
Willingness													There was evidence of conflict at shift manager level as to what constitutes a safe and unsafe condition for the plant. Therefore the willingness to shutdown should be reviewed across the whole operations team to ensure it is consistent and assess whether clearer guidance is required.
Management of operating procedures													There are plans in place for operators to be involved in writing procedures, for the procedures to be audited and for a new management of change system which ensures procedures are kept updated and out of date procedures recalled. It is also planned for the procedure control system to be reviewed and continuously improved. When these are implemented the operating area will progress up this ladder. It may be beneficial to tell people when new operating procedures are put onto the system as the site already does for new quality and SHE documents.
Management of change													Evidence from the study suggested that greater workforce involvement is required to progress up this ladder and evidence that changes can be reversed if it is found that safe control room operation is compromised. Additionally there is a need to use gap analysis on skills and assign resources for training prior to a change, for the control room to move to the left of the acceptable line on this ladder.
Continuous improvement of safety													Key requirement is for the investigations from incidents/events to be used in the review of training needs and operating procedures. This can be done in conjunction with the improvements to the training and development element. This again requires on the operators being available for participation in training activities which the current shift system makes difficult. Additional improvements should be planned after this has been achieved
Management of safety													Operator involvement in continuous improvement teams which tackle quality, environmental and safety issues would progress the operating area up this ladder.

Therefore the first priority actions are those identified for issues raised during the physical assessment. The next priority actions are those which will move the operating area to the left of the acceptable line in Table 3, in the areas of:

- Training and development.
- Roles and responsibilities.
- Willingness.
- Management of operating procedures.
- Management of change.
- Continuous improvement of safety.

The third priority are actions which will move the control room further up the ladders listed above plus the remaining elements of:

- Situational awareness (should be improved by actions required by the physical assessment).
- Teamworking.
- Alertness and fatigue (work pattern).
- Alertness and fatigue (health).
- Management of safety.

As with Case Study 2, the comment made by the site during the case study was that the control room had progressed approximately 2-3 rungs in the past 18 months due to the changes already made to control room operation plus areas such as management of operating procedures. Therefore the control room is in a transition phase and there are plans in place which should progress the control room up most of the ladder elements. The proposed changes to the shift system and the introduction of structured progressive skillsteps will be introduced as a package and these measures will improve the control room's position on alertness and fatigue (work pattern), training and development and roles and responsibilities.

Within the same package there are plans to introduce job rotation within the shift teams so that the current CRO's and senior operators rotate around the control room and outside plant operation. This will ensure a larger pool of fully capable CRO's who regularly operate the control panels plus better situational awareness due to regular experience of the outside plant plus control room DCS. This should assist in alertness and fatigue (work pattern) due to more flexibility for covering shifts plus better situational awareness.

The key differences between the control rooms in Case Studies 2 and 3 are:

- In Case Study 2 the operator has control room and plant duties so has a good understanding of the plant and equipment but is not always available for detection of incidents plus there are the associated lone working issues.
- In Case Study 3 the CRO does not rotate jobs and spends all his time in the control room. Therefore although existing CRO's have previously been outside plant operators, they rely on training on changes in plant equipment to retain familiarity with the plant. A DCS mimic and even a P&ID do not convey the level of information gained from seeing the item of plant equipment and being able to visualise its operation. There also appears to be less involvement of CRO's in writing procedures and the assessment and implementation of change.

Therefore the batch operating area is stronger in some different areas to the continuous operating area, best practices should be shared across the site.

<u>Issues raised about the assessment method</u>

Physical assessment: As in Case study 2, progress was made on the specification of scenarios in terms of the number, type and level of detailed description required i.e. the need to identify scenarios which could result in incidents with major hazard potential. There should be no fixed rule on the number of scenarios that should or must be analysed - each plant or unit is different. It is recommended that scenarios representing the following are analysed:

- Worst case scenarios requiring implementation of the off-site emergency plan;
- Incidents which could escalate without intervention to contain the problem on site;
- Lesser incidents requiring action to prevent the process becoming unsafe.

A site will also need to consider whether it is necessary to assess the scenarios at different times such as during the day and at night, during the week and at weekends, if staffing arrangements vary over these times.

It is necessary to define the circumstances of each scenario in sufficient detail. As a minimum:

- Define who is controlling the process and their starting locations;
- Define who is available to support the incident, and their starting locations:
- Define the parameters that determine the time available to the operations team for detection, diagnosis and recovery. Therefore parameters such as process conditions, leak point, wind direction, release rate, time of day, may need to be defined.

Sites should gather any historical data that is relevant to the detection, diagnosis and response to the selected scenarios.

It was possible to identify areas where although the staffing arrangements were assessed as acceptable there was the opportunity for improvement.

Ladder assessment: The ladders used during the case study were slightly different from those used to present the results due to consultation with the HSE and the case study sites. However it has been possible to use the information collated during the case study to complete the ladder. The need for an introduction to each ladder element to explain the approach and key issues being explored was confirmed during this case study.

As seen in Case Study 1 the different responses to questions and ladder positions confirmed the need for a team approach to assessment of ladder elements so that a consensus can be achieved, followed by peer review so that the assessment outcome is owned by all people affected.

Additionally the study highlighted the need to provide guidance which advised people to place the production area on the rung which represents the current situation not the future.

Case studies 2 and 3 highlighted that areas controlled by different control rooms on the same site could give different assessment results and therefore require separate assessment. The organisational structure in each production area and the degree of interaction across areas for each assessment element will determine the similarities in the assessed position for different production areas on the same site.

APPENDIX F

Summary of feedback questionnaires from industry seminar

Industry seminar 11th September 2000

Feedback questionnaire

16 respondents:

- 1 representative from a contract organisation
- 1 CIA representative
- 14 industry representatives

Feedback on the method

For each of the statements below, please tick the box which best describes how you feel. Plus, please insert any additional comments you may have in the space provided.

	Disagree strongly	Disagree	Agree	Agree strongly
1. The method is easy to understand	0%	6%	75%	19%

Comments: *The "ladder" principle is an easy concept to work with.*
Few guidelines required - definitions. Maybe some sort of % score that gives an indication of grade.
The ranking of 'rungs' on the ladders does not always fit particular situations.
The principles are easy to understand, but I feel that certain area (e.g. trees) require more explanation.
Information pack does not give enough detail on 'trees'.
Confusing early on but discussion in workgroups helped. The method may need to be made more reader friendly.
As long as the definitions of what you are assessing are clear.

	Disagree strongly	Disagree	Agree	Agree strongly
2. I understand the main objectives of the method	0%	0%	81%	19%

Comments: *Discussion with other attendees identified that task analysis would add benefits to the overall process/assessment.*

Proactive approach to manning levels.

Once control room definition was explained.

	Disagree strongly	Disagree	Agree	Agree strongly
3. It is appropriate that the method covers technical, individual and organisational factors	0%	0%	81%	19%

Comments: *All have an input into overall control room / operator interactions especially on COMAH sites.*

Should not be treated in isolation.

4. It is appropriate that the method assesses whether there are sufficient operating staff plus whether the management of staffing arrangements is sufficient

Disagree strongly	Disagree	Agree	Agree strongly
0%	0%	69%	31%

Comments: ………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

5. The method should help to identify areas of unacceptable risk in staffing arrangements where action is required

Disagree strongly	Disagree	Agree	Agree strongly	Don't know
0%	0%	81%	13%	6%

Comments: *Uncertain whether the assessment method addresses this area fully.*

Need guidance on where this is on 'ALARP' - HSE should provide this input.

Possibly

Need to see the whole process in "live" situation to comment.

Not simply unacceptable risk but also looking for continuous improvements when you are looking at the ladders.

<u>The next question requires a yes/no answer</u>

6. Would you like to apply the method on your site(s)?

Yes	No	N/A
69%	6%	25%

Comments: *Case study member.*

Believe it could be of benefit.

Has already been applied on one of our sites (case study member).

We need to seek advice but I guess the HSE will expect this?

Following more training, for example, on the method.

Will Entec provide skilled facilitators if requested?

It would seem to fit into the work that is already in progress.

Feedback on the guidance

For each of the statements below, please tick the box which best describes how you feel. Plus, please insert any additional comments you may have in the space provided

7. The guidance is understandable and easy to follow

Disagree strongly	Disagree	Agree	Agree strongly	DOn't know
0%	16%	72%	6%	6%

Comments: *The guidance would benefit from better definitions of some terms used.*

Difficult to assess fully without attempting a review.

A lot of detail to fit in at a one day seminar.

The published material is very useful.

Some clarification needed. This would be clearer with further study of the guidance.

Yes, but definitions could be clearer.

8. I would feel comfortable applying the method on my site(s) without external assistance

Disagree strongly	Disagree	Agree	Agree strongly	N/A	Don't know
0%	31%	50%	0%	13%	6%

Comments: *I would require assistance from a resource point of view and a "pilot study" would be helpful.*

I appreciate that this is the first attempt is to feel the temperature of the water so improvements awaited!

Need to discuss in more detail with operational staff.

Have Entec thought of providing training on the methodology?

I believe in the first instance, external guidance would be useful to make sure we are on the right lines.

<u>The next question requires a yes/no answer</u>

9. Would you like to have more guidance or support before you apply it?

Yes	No	No answer
50%	19%	31%

Comments: *A wider workgroup session (perhaps a day) would provide me with greater confidence before presentation to management.*

Would like updated ladders etc. after today's inputs from industry.

Other employees within my company may need guidance. Will there be any training courses?

I see the role of facilitator as key in this process. Training of facilitators is critical. What suggestions do you have for this training?

If I had a site, I would need more training, given that only a sample of documentation was considered.

Clearer definitions e.g. job description - what should be included?; operating procedures - what should be there for a manual plant and an automatic plant?

Any other comments: *Very good seminar. Pilot study exercise very useful to company. Very useful for COMAH demonstrations. It also gave an insight into potential problems and the need to produce an action plan to remedy them.*

The workshop session was extremely useful and enhanced understanding of the ladders and the method.

The system as presented is very subjective and dependent on the auditor. Some form of scoring would be very useful.

A very interesting day. Thank you.

The seminar was very useful and constructive. The material that was presented gave a good overview of the method.

Thanks.

Some best practice on issues assessed or a contact list where best practice can be found.

Thank you very much for your participation in today's seminar. Please pass the completed form back at the end of the day.

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