EQE INTERNATIONAL

REPORT ON THE

JOINT INDUSTRY PROJECT ON

HUMAN FACTORS IN OFFSHORE OPERATIONS

Project No. 59122.01

Final Report

December 1997

EQE INTERNATIONAL

EQE INTERNATIONAL

Engineering
Risk ▪ Safety ▪ Design

December 30, 1997

Transmittal No.:RJV-97-412

Minerals Management Service
Technology Assessment & Research Branch
Attn: Dr. Charles Smith
381 Elden St., M/S 4700
Herndon, VA 22070

Subject: Human Factors JIP Final Report

Dear Dr. Smith:

Enclosed is the final report on the Joint Industry Project (JIP) on Human Factors in Offshore Operations. The report consists of:

- JIP on Human Factors in Offshore Operations Report
- Crane Study
- United Kingdom Literature Search
- United States Literature Search
- Shift Work & Work Schedules
- Role Evaluation Tool
- Preliminary Human Error Assessment Tool
- Completed Forms on Human Error Assessment of Offshore Crane Operations
- Revised Human Error Assessment Tool

Also, included is a electronic copy of the report.

We appreciate your participation and effort and look forward to working with you again in the future.

Sincerely,
EQE International

Lana E. Jordan
for Jack Vernon, PE CSP
Technical Manager

RJV\lej

Enclosures

16850 Diana Lane ▪ Houston, TX 77058 USA ▪ Telephone (281) 480-3800 ▪ FAX (281) 480-0070

TABLE OF CONTENTS

INTRODUCTION

In the third quarter of 1994, the U.S. Minerals Management Service (MMS) accepted a proposal by EQE International to develop a joint industry project (JIP) on human factors in offshore operations. The project was to be one of several being sponsored by the MMS to investigate Human and Organizational Factors in the Offshore Petroleum Industry.

The originally stated objective of the JIP was to identify or develop tools for human factors/error assessment that would be appropriate for offshore activities. The tools should be appropriate for use by offshore personnel with minimal training (i.e., it would not be necessary to used trained psychologists or ergonomists to apply the tools).

The goal of this JIP was to develop tools that offshore operators could use to analyze offshore activities for human error potential and to subsequently develop corrective measures to reduce the error potential. The focus of the project was to identify those potential human errors that could be reduced through job redesign, procedure redesign, or training. As a result, the targeted users for tools developed by the JIP are the currently installed base of offshore facilities.

Project participants were solicited through late 1994 and all of 1995. The final project participants are:

- U.S. Minerals Management Service
- National Energy Board of Canada
- Health and Safety Executive (U.K.)
- Exxon Production Research Company
- Texaco, Inc.
- Sedco Forex Limited
- Chevron UK Limited
- Amerada Hess Limited
- ORYX UK Energy Company

EXECUTIVE SUMMARY

To assess the status and applicability of human factors assessment tools to the offshore industry, the JIP investigators performed the following broad project tasks:

- Literature search of existing human factors assessment tools with a focus on application to the offshore industry
- Survey of JIP participants to determine existing activities in the area of human factors assessment
- Attendance at MMS sponsored seminars and conferences on Human and Organizational Factors in the Offshore Industry
- Development of a Role Evaluation Tool
- Development of a Human Error Assessment Tool (preliminary)
- Application of the Human Error Assessment Tool to offshore crane operations
- Refinement of the Human Error Assessment Tool

The literature search and participant surveys indicated that the application of human factors (HF) assessments to the offshore industry is in its infancy. Where HF assessments had been attempted, the results of the studies had been discouraging. This was mainly because the recommendations that had resulted from HF studies were frequently too general to be helpful to the facility operators. Recommendations resulting from HF assessments frequently included such items as improved training, improved procedures, or improved personnel competency. The JIP participants agreed that such broad recommendations were not useful. Tools that provide more specific corrective measures are needed.

Human factors is often called the study of the man-machine interface. In broader terms, it can be thought of as the match (or mismatch) between the requirements of an activity and the capabilities and limitations of a human operator. These human capabilities and limitations may be individual, specific, or may apply to people in general. For example, if an activity requires an individual to crawl through a series of narrow ductwork, a small-framed individual might be capable of performing the task while a large-framed individual would not (individual specific capabilities and limitations). An example of an activity where people in general would display limitations is any activity requiring physical exertion for prolonged periods of time in areas where ambient temperature exceeds 130 F.

These simple examples suggest two very different approaches to human factors issues. These are:

- Matching humans to the job
- Matching the job to humans

In the first example, it's clear that given the constraint of the system, personnel selection is a key criteria in providing a match between the job requirements and the capabilities of the worker. In the second example, it's pretty clear that the job will need to be redesigned (i.e., the environment changed) in order for a human to be able to perform the task. If the environment cannot be changed, a machine that is not subject to human limitations could (and probably should) be used to perform the task.

Though useful for illustration, these examples oversimplify the field of human factors. In most cases, there is a balance between personnel selection and training (matching humans to the job) and hardware design, job design, and procedures (matching the job to humans).

To address the first approach (matching humans to the job), a Role Evaluation Tool was developed by EQE Limited in the UK. This tool is qualitative in nature and involves the evaluation of a job role by supervisory personnel and other experts. Role requirements and characteristics can then be compared to requirements and characteristics of humans to determine where possible mismatches occur. These mismatches present a high potential for human failure in job performance and should be focus areas for further evaluation of corrective measures.

Where absolute mismatches *do not occur*, the Role Evaluation Tool can help identify ranges of physical and/or cognitive skills that are best suited for a particular job role. If specific physical or cognitive skills are identified, it may be appropriate to list these skills as job requirements during the candidate selection process. Candidates can then be screened against this list to prevent hiring persons that are incapable of performing necessary job requirements (this is actually a common practice in business, but job roles are not evaluated at the level of detail suggested by the Role Evaluation Tool).

The Role Evaluation Tool can also be used to identify psychological factors that may influence job performance. Once identified, candidates could be subjected to psychological tests as part of the employment screening process. Though these factors may in fact be important in personnel selection, they are difficult to measure and correlate with job performance. As a result, U.S. employers have shied away from the use of psychological tests for fear of discrimination lawsuits by rejected candidates. However, the use of such tests may be appropriate in other countries and selection and validation of psychological tests is an area that may warrant further study.

The Human Error Assessment Tool (HEAT) was developed by EQE Americas Group of San Francisco and Brackett and Associates of College Station, Texas. The tool combines methods from various human factors assessment techniques and can be used to analyze a specific activity for human error potential. The aim of the tool is to identify areas where job redesign, personnel retraining or procedure redesign can reasonably be expected to reduce the potential for human error during performance of the activity (matching the job to humans).

The HEAT is a three-step process involving Gross Task Analysis, Human Error Identification, and Error Analysis and Corrective Measures. It's important to note that the first two steps of the HEAT are minor variations of techniques that are currently widely accepted and used in the oil industry. The third step – Error Analysis and Corrective Measures – introduces the use of the information processing model illustrated in Figure 1 to correlate specific causes of human error with possible corrective measures. The HEAT methodology includes several forms and guidelines that lead the user through the steps necessary to perform the assessment and develop specific corrective measures.

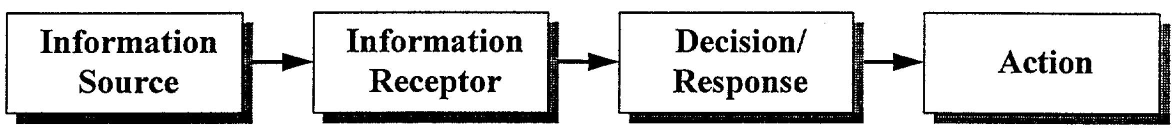


Figure 1: INFORMATION PROCESSING MODEL

Included as a supplement to this report is a report on the application of the HEAT to offshore crane operations. While the main purpose of this pilot test was to refine the methodology to be more appropriate for use by offshore personnel, the pilot test report illustrates the level of detail and types of corrective measures that could be expected from future applications.

The concepts and methods outlined in the Role Evaluation Tool and the Human Error Assessment Tool are consistent with current research (and previously published methods) in human factors assessment. Although limited application of the HEAT indicates that the level of detail, resources, and training needed to apply the tool is appropriate to the offshore industry, additional pilot studies are needed to demonstrate its ultimate usefulness in reducing human error. The JIP investigators encourage additional applications within participating companies as a way to further refine the tool.

PROJECT HISTORY

The following specific project tasks were performed by the JIP investigators:

Solicitation of Participation

Human Factors Status Assessment

Selection/Development of Tools for Pilot Testing

Application of the Human Error Assessment Tool to Offshore Crane Operations

Refinement of the Human Error Assessment Tool

More detailed discussions of these project tasks are presented below.

SOLICITATION OF PARTICIPATION

EQE International developed a preliminary scope of work in order to solicit participation for the JIP. The preliminary scoping and solicitation effort was a combination effort between EQE Americas Group (EQE International), and EQE Limited in the United Kingdom. Candidates for participation included U.S. and U.K. operating companies, offshore contractors, offshore engineering design companies, and regulatory agencies. The preliminary scoping and solicitation efforts were funded through the initial project grant provided by the U.S. Minerals Management Service.

During the participant solicitation process, the preliminary scope of work was modified to accommodate the interests of potential participants. In addition, two levels of participation were established. The first level of participation provided for access to all project reports and findings and was established at a cost of US $12,000. The second level of participation included membership in the JIP Steering Committee and the cost was set at a US $18,000.

EQE solicited participation from approximately 50 operating companies, contractors, design firms, and regulatory agencies. The solicitation process took approximately one year and resulted in the following participants.

- U.S. Minerals Management Service (Steering Committee)
- National Energy Board of Canada (Steering Committee)
- Health and Safety Executive (U.K.)
- Exxon Production Research Company (Steering Committee)

- Texaco, Inc. (Steering Committee)
- Sedco Forex Limited
- Chevron UK Limited
- Amerada Hess Limited
- ORYX UK Energy Company

BP Production, Alaska was initially signed on as a Steering Committee participant, but subsequently dropped out of the JIP after they determined that the project would not meet company-specific goals regarding analysis of shift duration and work schedules.

HUMAN FACTORS STATUS ASSESSMENT

EQE performed two literature searches to gather data on the status of human factors assessment application to offshore operations. One of these literature searches was performed by EQE Limited and searched several information sources in the United Kingdom. The second literature search was subcontracted to Brackett and Associates and included information sources in the United States. In addition to the literature searches, project participants were questioned to determine the level of human factors assessment application that currently existed within individual companies.

Appendix A contains the results and discussion of the literature search that was performed by EQE Limited. This literature search identified several human factors assessment techniques that were judged to be possibly applicable to offshore activities.

Appendix B contains the results and discussion of the literature search that was performed by Brackett and Associates. This literature search identified some additional human factors assessment techniques as well as basic information about activities that were candidates for future pilot studies.

None of the identified techniques had been widely applied within the offshore industry. In addition, approximately half of the techniques identified focused on the quantification of human error probabilities. The remaining qualitative techniques used a combination of task analysis, functional analysis, and HAZOP-type reviews to identify error-likely situations.

In addition to the literature searches on human factors assessment techniques, Brackett and Associates performed a literature search on shift work and work schedules. This subject was an area of common interest for the JIP participants. The results and discussion of this search are presented in Appendix C.

SELECTION/DEVELOPMENT OF TOOLS FOR PILOT TESTING

The results of the literature search in the company surveys were compared to the project goals and participant needs to identify appropriate tools for use in the pilot testing phase. The literature search identified approximately 20 published human factors assessment methods, none of which had been designed specifically for the offshore industry. Also, none of these methods had been used extensively by participating companies.

Complicating the selection of appropriate tools were the differing needs between the U.K. and U.S. participants. Due to the need to perform safety cases, the U.K. participants had some previous experience in the evaluation of available HF techniques. These techniques have not seen extensive use due to the lack of validation. This was in contrast with U.S. participants, who had little experience with published human factors assessment techniques.

As a result of the differing needs of the participants, two qualitative tools were developed. A Role Evaluation Tool was developed by EQE Limited to qualitatively evaluate job roles for human factors issues. A Human Error Assessment Tool (HEAT) was developed by EQE International to evaluate specific offshore activities for the potential for human error. Although related, these two tools approach human factors from different perspectives.

The Role Evaluation Tool provides a high level view of a job role to identify psychological, physiological, and physical factors that may influence job performance. Once identified, these factors become focus areas for further evaluation.

The HEAT focuses on a specific activity within a job role to identify likely sources of human error while performing the activity. While recognizing that each individual performing an activity has a unique psychological make-up that can result in random human error, the JIP investigators believe that this type of error is virtually impossible to predict and control. As a result, the focus of the HEAT is to identify system induced, or systemic, errors that have a reasonable likelihood of occurrence regardless of the individual who is performing the activity. By identifying and correcting the systemic errors, the risk of human error can be reduced to a tolerable minimum.

Role Evaluation Tool (RET)

None of the human factors assessment techniques identified through the literature search provided a comprehensive assessment of the possible mismatches between job role requirements/characteristics and human requirements/characteristics. This assessment was a special interest area of the U.K. participants. Due to the limitations of the existing techniques, the JIP investigators developed a Role Evaluation Tool to meet the needs of the U.K. participants.

The Role Evaluation Tool is included as Appendix D of this report. The RET uses a series of questions presented in four tables to define the requirements and characteristics of a work role. Once identified, these are compared to human requirements and characteristics in order to identify psychological, physiological, and physical factors that may affect performance of the role.

Application of the Role Evaluation Tool results in a list of factors that may negatively impact human performance in the role. This may include:

- Psychological - those factors that can negatively influence concentration, memory, or attention
- Physiological factors - those factors such as excessive heat or excessive cold that may overstress the human physiology
- Physical factors - those factors associated with the human body such as muscle built, height, and girth

A major drawback to the use of the RET in the United States is the potential need for psychological, physiological, and physical testing to resolve issues identified by its application.

Although physical factors have traditionally been an issue for some types of hiring, there is an increasing pressure within the U.S. to redesign jobs to accommodate the individual physical limitations of job applicants. Where an employer can demonstrate that such accommodation is not feasible given the nature of the job, candidates with specific limitations can be eliminated from consideration.

The use of psychological testing for candidate selection is more problematic. In order to avoid potential discrimination lawsuits, an employer must validate psychological tests to show a strong correlation between test performance and job performance. Such validation can be costly. It can also be impractical unless a large body of candidates can be tracked through the hiring process and subsequent job performance.

Human Error Assessment Tool

Several of the identified human factors assessment techniques identified through the literature search were candidates for human error evaluation of offshore activities. Probably the closest match to the JIP requirements is the System for Critical Human Error Management and Assessment (SCHEMA). The SCHEMA methodology is as follows:

- Hierarchical Task Analysis for Problem Definition

- Human Error Analysis which identifies action errors, checking errors, retrieval errors (information from displays, procedure, and memory), transmission errors (communication between individuals), selection errors
- Qualitative Screening
- Quantitative Assessment
- Suggested Risk Reduction Strategy Implementation and Monitoring of Results

The HEAT contains several element that are analogous the SCHEMA elements. The quantitative assessment element of SCHEMA has been eliminated and risk reduction element has been modified to be more appropriate for the offshore user.

The latest version of the Human Error Assessment Tool is included as Appendix E to this report. In addition, a supplemental report entitled "Report on the Application of a Human Error Assessment Tool to Offshore Crane Operations" is available through the JIP.

The HEAT approach involves examining the individual steps that people perform when conducting an activity in order to identify potential human errors. Once identified, each error is in subjectively analyzed and rated for potential impact to system performance as well as likelihood of occurrence. Rating the errors provides the means to prioritize errors for application of the Error Analysis and Corrective Measures. Only high priority errors become the focus of this analysis, since eliminating these errors will result in the greatest overall system improvement.

Application of the HEAT involves three main steps:

- Gross Task Analysis
- Human Error Identification
- Error Analysis and Corrective Measures

Appendix E contains the specific procedures for each of these steps along with the associated guidelines and forms necessary to perform a HEAT analysis for an activity. The reader should note that, of the three main steps involved in HEAT, two steps (Gross Task Analysis and Human Error Identification) are slight variations on methods currently used in the offshore industry for other purposes. The human factors analysis occurs during the Error Analysis and Corrective Measures step of the method. As a result, an offshore operator could substitute his own variation of these first two steps into the Human Error Assessment Tool without losing benefit of the human factors analysis.

The Error Analysis and Corrective Measures step is based upon an information processing model consisting of an information source, information reception, decision/response, and action. The technique seeks to identify deficiencies within these model elements, or the links between the elements. These deficiencies then become the focus of possible corrective measures. For a complete explanation of the HEAT, refer to Appendix E.

APPLICATION OF THE HUMAN ERROR ASSESSMENT TOOL TO OFFSHORE CRANE OPERATIONS

The preliminary Human Error Assessment Tool was used to evaluate offshore crane operations for a Gulf of Mexico operator. The purpose of the pilot application was to evaluate the procedures, forms, and guidelines in the preliminary HEAT and to identify areas of improvement to make the tool more user friendly. A separate report entitled "Report on the Application of a Human Error Assessment Tool to Offshore Crane Operations" is available through the JIP.

PROJECT CONCLUSIONS

While the efforts of the Joint Industry Project on Human Factors in Offshore Operations are an important first step toward introducing human factors into the operations side of the industry, the methods require additional refinement through application. In addition, barriers to their acceptance should be recognized and addressed to facilitate their use.

The traditional approach to reducing human error in oil industry operations is to establish procedures and then audit to verify that procedures are followed. While auditing can be very effective in reducing certain types of errors (violations), it cannot address sources of error that have been unintentionally *designed* into the activity. These booby traps must be systematically identified and eliminated before the audit function becomes truly effective.

In an industry where personnel resources have been repeatedly stretched, there is natural resistance to the introduction of a new method for 'making things better.' The JIP investigators discussed this fact with several offshore personnel that they met during the course of the project. In several cases, operating personnel expressed concern over yet "another audit" of their facility.

Each company that is committed to additional use of human error assessment in their operations should consider pilot studies that include both assessment ***and*** implementation of identified corrective measures as a way to develop a convincing 'marketing presentation' to the organization. The tools can only be further refined if they are applied, and the they will only be applied if the end user can clearly see examples of their benefit. As a wise old (sales)man one said, "It's not *what* you sell, it's *how* you sell it.

HUMAN ERROR ASSESSMENT TOOL TO OFFSHORE CRANE OPERATIONS

TABLE OF CONTENTS

REPORT ON THE APPLICATION OF A HUMAN ERROR ASSESSMENT TOOL TO OFFSHORE CRANE OPERATIONS

INTRODUCTION

This report presents the results of the application of a Human Error Assessment Tool (HEAT) to offshore crane operations. The HEAT was developed under the Joint Industry Project for Human Factors in Offshore Operations (JIP). The purpose of this pilot study was to apply the tool to an offshore activity in order to determine which aspects of the tool are appropriate for offshore operations and which aspects of the tool should be modified to improve ease of use or make the tool more appropriate for the intended user.

Human factors (HF) analysis is directed toward the human-machine interface. The goal of human factors analysis is to identify features of the human-machine interface that can result in system induced human error and to modify these features to reduce the likelihood of that error. The HEAT developed by the JIP is designed to allow the user to identify critical errors and to analyze those errors based on human factors principles. The best corrective measure for the error can then be determined based upon the identified human factors cause.

The focus of the JIP is to identify errors in existing systems that can be corrected by job redesign, procedure redesign, job aids, or training. However, the reader should note that in some cases, the underlying cause of human error is best corrected by a redesign of the human-machine interface itself. Thus, a secondary focus of the HEAT is to gather information to identify areas where modification of design standards or more detailed specification of manufactured equipment is warranted.

SCOPE

This pilot study analyzed general offshore crane operations with a focus on moving loads from service vessels to the platform and vice versa. The study did not focus on any particular crane or crane cab design. Instead, the steps to accomplish movement of a load were identified, followed by identification of possible errors that could occur within those steps.

METHOD

The preliminary Human Error Potential Assessment Tool dated November 1996 was applied to offshore crane operations. (The title of the tool was subsequently modified to eliminate the word "potential.") A copy of this preliminary tool is included as Appendix A to this report. The major elements of the HEAT are described below.

Gross Task Analysis

The Gross Task Analysis is used to define the tasks and steps that must be conducted to accomplish the activity of interest. The results of the Gross Task Analysis represent an outline of the procedure for the activity.

Human Error Identification

Several techniques are used to identify human errors that can occur when performing the procedure steps identified in the Gross Task Analysis. These are:

- Brainstorm possible errors
- Review Accident History
- Conduct Personnel Interviews

Human Error Identification includes a system to rate likelihood and consequences of error in order to identify critical errors for Error Analysis and Corrective Measures.

Error Analysis and Corrective Measures

Error Analysis is only performed on those identified errors that have a high risk index. The Error Analysis involves classifying the errors according to an information processing model. This model assumes that errors can occur at one or more of the following points in the information processing chain:

- Information Source
- Information Channel (Information/Human Interface)
- Information Processor (Operator)
- Output Channel (Human/Control Interface)

- Action (Manipulation of Control)

Identifying corrective measures involves determining the likely causes of error and then making cause-specific recommendations to reduce the potential for error. The corrective measures could involve job redesign (reducing workload; specifying additional operator skills; etc.), procedure redesign (add, remove, or re-sequence steps), job aids (memory joggers; enhanced labeling; etc.), training, or equipment redesign.

DISCUSSION OF HEAT APPLICATION

General

The Human Error Assessment Tool as described in Appendix E was applied to offshore crane operations. The forms prepared during the pilot study are included as Appendix G.

The gross task analysis, including possible error identification and assignment of likelihood and severity values, was accomplished during approximately 12 hours of meeting between the JIP resources and the subject matter experts.

During the first 4 hours of meeting, two subject matter experts were available. The following 8 hours of meeting were accomplished by using a single subject matter expert. A review of the available accident history was also conducted during this meeting. These previous accidents were categorized by the analysis team according to their judgment as to the human error that occurred.

A drawback to the Human Error Assessment Tool is the degree of documentation that it requires. The current version of the tool requires that task, step, possible error, and severity and likelihood ratings information be documented on forms. This may not be very practical in a group meeting environment, the drawback being that meeting participants cannot see the information after it is generated.

During this pilot study, flip charts were used to collect the information during team meetings. The information was subsequently transferred to forms. This has the advantage that the information can be clarified as it is transferred but the disadvantage that the information is essentially documented twice. Some options for reducing the work required for documentation are:

- On-line documentation that can be easily edited

- Use of white boards equipped with scanners to provide hard copy
- Where detailed procedures are available, forms can be prepared prior to group meetings

Gross Task Analysis

Detailed procedures for offshore crane operations were not available. As a result, the procedure outline was developed using the available subject matter experts. The team used a white board to outline the tasks associated with offshore crane activities. These tasks were then broken down into the steps required to accomplish each task and were documented using flip charts.

The need to develop procedural outlines for activities to be studied is probably typical. Even where detailed written procedures are available prior to the start of the study, displaying the procedure outline for team review and comment can be used to bound the scope of the HF assessment.

Suggestions for Future Pilots

As a result of Pilot Study #1, the Gross Task Analysis procedures have been modified as follows:

- Additional guidance on conducting the Gross Task Analysis in a meeting environment was added.

Human Error Identification

Brainstorm Possible Errors

Once the tasks and steps for offshore crane operations were identified, brainstorming possible human errors proved to be relatively simple. After the possible errors for each step were identified, the team judged the likelihood of error and the error consequences based on the rating scheme in the HEAT.

Likelihood and Consequence Rating

Rating the likelihood of identified errors using the scheme in the HEAT also proved to be straightforward. However, rating the consequence of error occurrence is not quite as easy. A team can rate the direct and immediate outcome of an error, the worst-case outcome of an error, the most likely outcome of an error, or a weighted (expected) outcome. During this pilot study, the team was directed to rate the most likely outcome of the error. However, a review of the ratings for various errors indicates that the consequence ratings are inconsistent and do not always accurately reflect the effect of latent errors (i.e., those whose consequences are delayed until a later task).

In the HEAT, the base risk index is subsequently modified based on accident and incident history and the modified risk index is used to identify critical errors. As a result, it is important that the HEAT provide some means to track latent errors to ensure they are not overlooked in the final analysis. Although the current rating system is appropriate if used properly, the JIP should evaluate alternatives to determine if a simpler rating system can be used to identify critical errors.

Review of Accident History

The evaluation team was provided a summary of offshore crane related accidents from 1994 - February 15, 1997. This summary included information on the type of loss (property, injury), approximate cost of the accident (if known), the phase of crane operation (lifting, securing, lowering, etc.), and a short description of the accident. The review of the accident summary was performed in approximately 1/2 hour.

This information was sufficient to determine which of the previously identified errors was applicable to the accident. Based on this information, the base risk indices were modified and critical errors identified. No previously unidentified errors were noted during the accident summary review.

Critical Incident Interviews

The current version of the HEAT contains a form to document critical incident interviews. During this pilot study, these interviews were conducted at an offshore platform during work breaks with platform personnel. The interviewers did not document the interviews in the formal manner implied by the forms but instead conducted informal interviews to verify that earlier steps in Human Error Identification had properly identified the critical errors associated with crane operations.

These interviews did not result in identification of additional likely errors that had not been considered by the analysis team. Interviewees did offer some suggestions for possible solutions to identified errors.

Suggestions for Future Pilots

As a result of Pilot Study #1, the Human Error Identification procedures have been modified as follows:

- The procedure was modified to require the use of brainstorming plus **either** Accident History Review **or** personnel interviews to confirm that the brainstorming was thorough in identifying possible errors. This change was made in recognition that offshore personnel will obtain diminishing returns from the additional human error identification techniques. As a result, the procedure now gives the analysis team the option to choose the most appropriate combination of techniques for each specific study.

- Develop alternative means to identify critical errors (rating system), including some means to track latent errors, and do a side-by-side comparison with the current rating system to identify the method that is the easiest to apply.

Error Analysis and Corrective Measures

Error Classification and Causation

The HEAT proposed an error classification scheme according to an information processing model. The purpose of the classification is to better understand the underlying causes of error so that the most appropriate corrective measures can be determined. The guidance provided to perform this classification was limited and as a result, this step in the process was a bit confusing. The JIP resources concluded that additional guidance is required before a team leader with minimal training could properly classify errors.

Corrective Measures

Once the errors were properly classified and the possible causes for the errors were identified, determination of corrective measures was straightforward. The key is to identify possible corrective measures that modify the system in such a way as to eliminate the specific system-induced cause of human error. For example, errors that result from poor visibility during night time crane operations can be improved by installing and/or maintaining boom mounted lighting systems.

Suggestions for Future Pilots

- Streamline the information processing model to facilitate understanding by less experienced analysis teams.
- Provide improved guidelines for classifying errors into the various human factors cause categories.
- Provide improved guidelines for relating human factors cause categories to possible corrective measures.
- Reduce the number of forms required to analyze errors and identify possible corrective measures from 2 to 1.

MODIFIED HUMAN ERROR ASSESSMENT TOOL

Where appropriate, the HEAT has been modified based on the information obtained during pilot study #1. The modified procedures, forms, etc. are included in Appendix G to this report.

The specific modifications are:

- The procedures for Gross Task Analysis have been expanded.
- The Error Analysis, Accident Analysis, Critical Incident Interviews, and Error Rating have been combined under the category Human Error Identification. The focus on HF Analysis has been deferred until the final step in the process.
- The information processing model has been streamlined and additional guidance has been developed. The guidance has been embedded into the Error Analysis and Corrective Measures form to facilitate application by the analysis team.
- Additional guidance relating the type of error to appropriate corrective measure categories has been developed.

RESULTS OF OFFSHORE CRANE OPERATION ASSESSMENT

The results of the offshore crane operation assessment are represented on the forms contained in Appendix F.

The Gross Task Analysis, including possible error identification and assignment of likelihood and severity values, was accomplished during approximately 12 hours of meeting between the JIP resources and the subject matter experts.

During the first 4 hours of meeting, two subject matter experts were available. The following 8 hours of meeting were accomplished by using a single subject matter expert. A review of the available accident history was also conducted during this meeting. These previous accidents were categorized by the analysis team according to their judgment as to the human error that occurred (Forms 1 and 2).

The analysis team visited an offshore platform following the Gross Task Analysis and Accident Summary review. During this visit, we observed a load being moved from the top deck to a lower deck. Part of this movement was a blind lift, requiring the use of a signalman between the crane operator and riggers.

The operation was typical for a platform with an active drilling rig. The crane crew consisted of a crane operator plus 2-3 riggers. This team had worked together for several years. This personnel arrangement is not common for a typical production platform, where crane operator and rigger experience and rigger availability vary widely.

While on the platform, the analysis team interviewed the contract crane operator as well as 3 production personnel that routinely operate cranes during the course of their normal duties. The information obtained during these interviews was not documented formally. It did, however, reinforce the information that had been developed during earlier phases of the study.

Critical errors (those with high risk indices) were then classified according to which stage in the information processing chain could induce or exacerbate the error (Form 4). Possible causes of each error and the likelihood of each cause were assessed and possible corrective measures identified (Form 5). Corrected actions may include procedure redesign, job redesign, job aids, training, or redesign of the human-machine interface. A summary of the critical error analysis begins on Page 10.

Interestingly, an internal study of offshore crane safety had recently been completed. This earlier study was done by a team of four company personnel meeting for approximately 2 days.

In comparing the results of the earlier study with those of the human error assessment, we noted that most of the errors were identified in both studies. However, the human error assessment tool requires a more thorough analysis of the cause of error and, as a result, may suggest corrective measures that are ultimately more workable.

For example, both studies indicated that failure to conduct pre-lift crane inspections is a critical error. Without benefit of the human error assessment, the corrective measure for this error might be "enforce the performance of a pre-lift crane inspection prior to each lift." This corrective measure may be appropriate and sustainable as long as a system for enforcement is established and maintained.

However, one reason for failure to conduct a pre-lift crane inspection is the urgency, real or perceived, created when a service vessel arrives without warning (failure to receive communication) or during a time where competing demands (high workload) tempt the operator to take short cuts.

If these situations occur frequently, it may be more appropriate to establish a back-up communication system (from boat to a continuously-staffed shore station with the shore station notifying the platform via telephone that sounds a horn on platform) or enforcement of a daily crane pre-check and operational check to be conducted during slack workload, regardless of whether crane use is expected.

Although these solutions may be less desirable from an absolute perspective, they may prove to be more workable and sustainable because they address the problems that actually confront the platform operator on a daily basis.

Summary of Critical Errors and Possible Corrective Measures
Offshore Crane Operations

Task	Step	Error	Causation Stage	Cause	Possible Corrective Measure
Prepare Equipment and Crew	Conduct pre-lift crane inspection	Failure to conduct pre-lift crane inspection	IP	Excessive workload, time constraints	Establish and/or enforce procedure to conduct daily crane checks during slack periods.
			IP	Possible consequences not understood.	Improve training and supervision. Establish mandatory checkpoints in procedure to "tickle" compliance.
			IC	Advanced notification of boat arrival not received	Provide backup ship-to-platform notification to ensure advanced warning is received.
Attach Load	Riggers move clear after attaching load	Riggers do not move clear of load	IP	Use of untrained riggers.	Ensure availability of trained riggers through manpower planning or contract specification.
Lift Load	Raising the hood (take up slack)	Winch up with sling wrapped around obstacles	IC	Crowded boat deck	Develop and implement specifications for cargo spacing on boat decks.
			IC	Poor deck illumination	Install and/or maintain boom lighting systems.

Causation Stage Legend: IS = Information Source, IC = Information Channel, IP = Information Processor, OC = Output Channel, OA = Output Action
Notes: (1) No corrective measure suggested due to low likelihood associated with this cause.

Summary of Critical Errors and Possible Corrective Measures
Offshore Crane Operations

Task	Step	Error	Causation Stage	Cause	Possible Corrective Measure
			IP	Use of untrained riggers.	Ensure availability of trained riggers through manpower planning or contract specification.
		Apply line tension before boom is centered over load.	OC	Operator selects wrong control lever	Modify crane controls to enhance control differentiation.
			OA	Operator cannot track vessel movement	Develop and implement criteria for conducting lifts to and from service vessels in high seas and adverse weather.
	Raising the hood (take up slack)	Winch up the wrong line	OC	Operator selects wrong control lever	Modify crane controls to enhance control differentiation.
Lift Load	Winch load off the deck	Winch up an improperly rigged load	IS	Improper sling used	(1)
			IS	Sling not properly attached	Ensure availability of trained riggers through manpower planning or contract specification.
			IS	Use damaged sling	(1)

Causation Stage Legend: IS = Information Source, IC = Information Channel, IP = Information Processor, OC = Output Channel, OA = Output Action
Notes: (1) No corrective measure suggested due to low likelihood associated with this cause.

Summary of Critical Errors and Possible Corrective Measures
Offshore Crane Operations

Task	Step	Error	Causation Stage	Cause	Possible Corrective Measure
			IS	Sling not load tested	Establish and implement and/or enforce practice to load test all new slings at onshore facilities before they are delivered offshore.
			IS	Incorrect sling angle	(1)
	Swing load clear of boat deck	Swing boom before load clears obstacles.	IP	Lifting loads from vessel in rough seas.	Develop and implement criteria for conducting lifts to and from service vessels in high seas and adverse weather.
			OA	Boat shifting during slow lift using load line	(1)
	Raise load above platform obstacles	Winch up too high	IS	Crane being operated with out of service anti two-block device.	Establish and/or enforce prohibition against using cranes with out of service anti two-block devices.
		Boom up too high	IS	Crane being operated with out of service boom kick-out device.	Establish and/or enforce prohibition against using cranes with out of service boom kick-out devices.

Causation Stage Legend: IS = Information Source, IC = Information Channel, IP = Information Processor, OC = Output Channel, OA = Output Action

Notes: (1) No corrective measure suggested due to low likelihood associated with this cause.

Summary of Critical Errors and Possible Corrective Measures
Offshore Crane Operations

Task	Step	Error	Causation Stage	Cause	Possible Corrective Measure
Lower and un-hook the load	Winch down the load	Winch down too fast	IP	Workload, time pressures	(1)
			OA	Operator applies excessive control action	(1)
Lower and un-hook the load	Rigger detaches slings	Rigger fails to properly secure slings ropes after detaching	IP	Rigger not aware that sling ropes may swing freely	Ensure availability of trained riggers through manpower planning or contract specification.

Causation Stage Legend: IS = Information Source, IC = Information Channel, IP = Information Processor, OC = Output Channel, OA = Output Action

Notes: (1) No corrective measure suggested due to low likelihood associated with this cause.

EQE-ISS
REPORT APPROVAL COVER SHEET

PROJECT NO: 3-28

REPORT NO: 3-28-R-01

TITLE: Joint Industry Project on Human Factors in Offshore Operations
UK Literature Review

CLIENT: EQE International Inc., Houston

ISSUE	DATE	PREPARED	REVIEWED	APPROVED
Issue 1	20/1/95	S.M. Gilbert Project Engineer	S.J. Lewis Principal Engineer	M.G. Holley Project Manager

ISSUE RECORD

ISSUE	DATE	DESCRIPTION
Issue 1	20/1/95	Issued for client comment

EXECUTIVE SUMMARY

A UK literature review has been conducted on behalf of EQE International Inc., Houston, in support of the Joint Industry Project on Human Factors in Offshore Operations. The types of information reviewed include past and current methods of human factors assessment; UK incident and accident data; and human factors issues concerning well control, service vessel operations and crane operations.

The review has focussed on identifying techniques that may be applied in the assessment of hazards associated with offshore activities. Summaries of potentially useful methods are presented with information concerning previous applications and possible advantages and disadvantages.

At present, human error data pertaining to offshore activities in the North Sea are scarce. The study has identified that the shortage of relevant information has been a factor in the general reluctance of the UK oil and gas industry to perform human reliability assessments of offshore activities.

CONTENTS

1.0 INTRODUCTION

A UK literature review has been conducted on behalf of EQE International Inc., Houston, in support of the Joint Industry Project on Human Factors in Offshore Operations.

The objective of the review was to identify, obtain and review published information regarding the impact of human factors on offshore operations. More specifically, the study concentrated on literature pertaining to conditions experienced by the UK offshore industry. The types of information that have been reviewed include:

- past and current methods of human factors assessment applied in the UK;
- UK incident and accident data;
- literature dealing specifically with human factors issues concerning:
    - well control;
    - service vessel operations; and
    - crane operations.

A coarse evaluation of techniques has been performed to identify those which have the potential to be applied in human factors assessment of offshore activities.

2.0 METHODOLOGY

Figure 1 illustrates the methodology employed in conducting the literature search and review.

The study has employed the resources of EQE's in-house libraries in Aberdeen and Warrington, and also those of Aberdeen City Library, Aberdeen University Library and Robert Gordon University Library. EQE's arrangements with these libraries have provided access to:

- each library's collection (books, journals, etc);
- CD-Rom databases;
- Bath Information Database System (BIDS); and
- British Lending Library (BLL) collection.

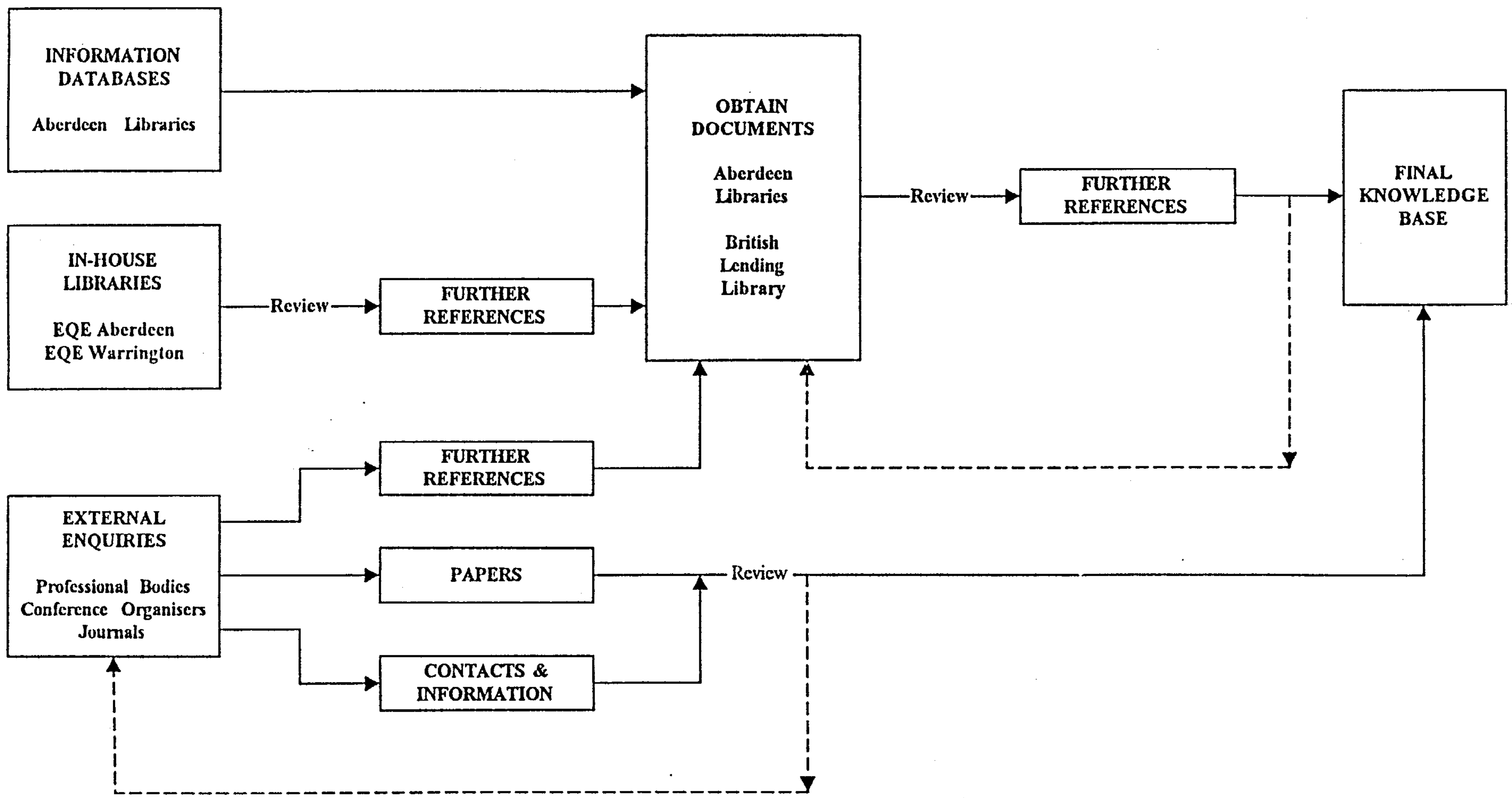
Information databases (COMPENDEX and Petroleum Abstracts) have been examined to generate a list of potentially relevant references. The following key phrases were employed in conducting the search:

- human error
- human factors
- human failure
- human reliability
- task analysis
- task modelling
- influence diagram
- blowout
- kick
- kick detection
- service vessel
- crane

A number of external agencies have also been contacted to establish further contacts, identify additional references and gather relevant human factors information and literature. These are listed in Table 1.

A schedule of the material obtained is presented in Table 2. There are also a number of documents which, although they may be relevant, we have not been able to obtain during the duration of the study. References to these documents appear in Table 3.

FIGURE 1. METHODOLOGY OF LITERATURE SEARCH AND REVIEW



3.0 REVIEW

3.1 Coverage

In accordance with the objectives, the literature search and review has been focussed on information pertaining specifically to offshore operations in the UK. However, a significant quantity of more general human factors literature has been developed in other sectors of industry and in different parts of the world. Hence, a selection of more general but relevant literature has been incorporated within the survey.

It is evident from the schedule of material obtained (Table 2) that a significant proportion of the literature has been published fairly recently. The review is considered to have featured much of the latest information available in the public domain.

The scope of the review was limited to published literature and, by definition, did not extend to proprietary information held in corporate libraries. However, this is acknowledged as a significant source of information.

Relatively little cross-referencing is observed within the population of literature surveyed. In the main, this may be attributed to the breadth of the subject area defined in the scope. The coverage may therefore be characterised as more broad than it is deep.

3.2 Human and Organisational Factors

In recent years, advances in engineering technologies and design of equipment have produced significant improvements in the integrity of production facilities. As a consequence of these 'hardware' improvements, an increasing proportion of incidents may be attributed to human error. This has resulted in greater examination of the contribution of human factors to the causes of incidents. Inevitably, the development of methods to reduce the potential for human error is attracting significant interest from industry and regulators alike. This is particularly the case in the offshore industry, where a high proportion of activities involve human interaction in some way, and where human failures have the potential to cause accidents of greater consequence than is perhaps the case in other industries.

In guidance for considering human factors in the control of risk, HSE (1993, ref.1) and the Engineering Council (1993, ref.2) describe three areas of influence which affect human performance - the organisation, the job and personal factors. The guidance encourages management to consider not only the errors individuals might commit, but also the underlying managerial and environmental conditions that contribute to the causation of accidents.

In a review of human errors in process safety, Wreathall (1993, ref.3) acknowledges that the human contribution to disasters is only partly specified by the human factors and organisational issues. One part missing is the context in which the actions take place. Work is only just starting in this area and, as yet, no methods exist to identify the specific conditions necessary to induce an error from an operator.

At this point a distinction may be made between techniques that are applied to address human factors at the *individual level* and those applied at the *organisational level.*

Methods that fall into the latter category may generally be described as audit-based, e.g. see Donald *et alia* (1991, ref.4) and Embrey (1989, ref.5). Many involve the use of questionnaires and structured interviews at various levels of the management system, followed by an analysis of the responses to provide an indication of the organisation's integrity as a whole. The subject of this type of assessment is usually an entire worksite. Examples of this type of assessment tool are:

- *MANAGER,* developed with HSE funding (ref.6,7);
- *FLAIM,* developed with US Minerals Management Service funding for assessing fire hazards offshore; and
- *TRIPOD*, developed for oil industry applications and funded by Shell (ref.8-11).

The remainder of this review concentrates on techniques aimed at addressing human factors at the *individual level.* The subject of this type of assessment is a specific task or activity. Organisational factors are only considered as they affect individuals' abilities to carry out the given task correctly and are treated as influences, or 'performance shaping factors'. The importance of any particular organisational factor may only become apparent once several activities have been assessed within a given worksite.

3.3 Human Factors in Hazard Assessment

Hazard assessment involves consideration of the combined influence of equipment (hardware) and human performance on system integrity. The following is an account of how human factors may be addressed within hazard assessment. The contribution of hardware reliability, although significant in affecting the system as a whole, is not the focus of this review. Elements of a human reliability assessment (HRA) may be summarised as follows:

Problem Definition.
The activity which constitutes the subject of the assessment is defined in terms of the system objective and the process by which it is achieved. In the context of hazard assessment, the system objective is defined in terms of a safety goal. This ensures that subsequent analyses are concentrated only on those actions which are relevant to the safe execution of the task.

Error Identification.
The model of the system is analysed to identify the potential for human errors to occur, their underlying causes and opportunities for recovery action. Various taxonomies and theoretical models of human errors exist, many of which form the basis for human error analysis techniques.

Representation.
The aim at this stage is to produce a clear and understandable representation of the system and failure-producing conditions. This should illustrate the potential for error-producing conditions to occur and how failures may be propagated through the system to produce undesirable consequences.

Assessment.
The consequences of human errors are analysed to estimate the system's capability of meeting its objective. The contributions of specific errors and their underlying causes are analysed in terms of their impact on overall system performance. An initial qualitative assessment may be performed to screen out errors with insignificant impact on safety. Selected failure conditions may then be subjected to further assessment, which could involve quantitative analyses.

Risk Reduction.
The aim at this stage is to identify risk reduction measures and assess their effectiveness in improving system reliability. This may involve some form of sensitivity analysis to demonstrate that the benefits of implementing modifications to reduce or control risk are cost-effective.

DeJoy (1990, ref.12) and Kirwan (1990, ref.13) also present generic methodologies for comprehensive human reliability assessment. Kirwan is a particularly useful document in that it defines what output is expected at each stage of the assessment and identifies the most prominent and promising of the methods available at the time, many of which are described below.

3.4 Techniques for Conducting Human Reliability Assessments

This section of the review is a summary of techniques which appear appropriate for analysing offshore activities. The principal sources of information have been identified and are reported here.

A framework for addressing the impact of human factors within hazard assessment is described in the preceding section. The techniques available are now summarised in terms of the elements just described. Some of the techniques cover many or all of the elements and some techniques are submethods of others. In practice the boundaries between elements of an assessment are not clearly defined, inevitably resulting in some overlap.

Hashemi (1992, ref.14) outlines the main human factor related issues affecting the safe design and operation of offshore installations and examines the effectiveness and practicality of considering complex human factor issues within safety studies.

The literature contains a number of publications which provide broad overviews of techniques in general.

The principal guide on task analysis is reputed to be Kirwan & Ainsworth (1992, ref.15). Part 1 provides an overview of the task analysis process, Part 2 describes 25 types of task analysis techniques, and Part 3 demonstrates the application of task analysis techniques using ten case studies. The guide divides the techniques into five categories:

1. task data collection methods, e.g. task observation; interviews; analysis of procedures; incident analysis; structured walkthroughs of procedures; and examination of system documentation;
2. task description methods, e.g. charting and networking; task decomposition; and hierarchical task analysis;

3. task simulation methods;
4. task behaviour assessment methods (error identification within task analysis); and
5. task requirements evaluation methods.

By encompassing all these aspects, the guide considers techniques within its definition of 'task analysis' that extend beyond the problem definition stage of human reliability assessment.

Williams & Munley (1992, ref.16) also discusses methodologies for identifying the potential for human error in industrial systems, and describes the limitations of current systematic techniques such as HAZOP-based approaches.

The Human Reliability Assessor's Guide (1988, ref.17) comprises a comprehensive survey and evaluation of eight techniques for quantitatively determining human error probabilities. Part 1 of the guide defines the criteria employed in the assessment while Part 2 provides detailed descriptions and evaluations of the techniques (APJ, PC, TESEO, THERP, HEART, IDA, SLIM and HCR) with illustrative case studies.

Kirwan (1990, ref.13) utilises some of the Human Reliability Assessors Guide findings as part of a broader overview of human reliability analysis.

Techniques that appear as though they may be used in the assessment of offshore activities include:

THERP - Technique for Human Error Rate Prediction;
IDA - Influence Diagram Approach;
SCHEMA - System for Critical Human Error Management and Assessment;
Task Analysis;
Function Analysis;
Link Analysis;
Human HAZOP (Hazard and Operability) Study;
SHERPA - Systematic Human Error Reduction and Prediction Approach;
PREDICT - Procedure to Review and Evaluate Dependency in Complex Technologies;
Sneak Analysis;
Event Tree Analysis;
Task Hazard Identification;
SHARP - Systematic Human Action Reliability Procedure;
APJ - Absolute Probability Judgement;
PC - Paired Comparisons;
HCR - Human Cognitive Reliability;
HEART - Human Error Assessment and Reduction Technique;
SLIM - Success Likelihood Index Methodology; and
TESEO - Tecnica Empirica Stima Errori Operatori.

The techniques are summarised below. Wherever possible, information concerning previous applications and advantages/disadvantages is included, together with a shortlist of the most relevant literature reviewed. Other references are summarised in Table 2.

THERP - Technique for Human Error Rate Prediction

THERP is a methodology which covers all elements of human reliability assessment. It was developed in the 1960's at Sandia National Laboratories to reduce the incidence of production defects in nuclear weapons development. Due, in part, to its age the method has been employed in many industrial applications, including offshore operations. It is typically applied to highly proceduralised tasks and features a database of human error probabilities which has found widespread use in probabilistic risk assessment.

Problem definition is by means of task analysis, with information gathered from systems analysts and from plant visits.

The identification of human failures is based on treating human components of a system as if they were analogs of machines, with simple failure modes. Hence, THERP tends to focus on identifying slips and lapses resulting in errors of omission. The method is limited in its ability to consider inappropriate but deliberate actions (errors of commission). THERP does, however, allow consideration of error recovery and, to a certain extent, dependency between human dependent failures.

Conventional event trees are employed to represent the propagation of errors through the system.

THERP allows quantitative assessment of human reliability by employing the database of human error probabilities.
The data are based on a mixture of field experience and expert judgement and relate to manual actions. They do not explicitly cover cognitive error probabilities.

Finally, THERP allows a reevaluation of system failure probability based on recommended changes being implemented.

Due to its popularity, THERP has been the subject of a great deal of scrutiny - perhaps more than other techniques.

Criticisms of the method include:

- the resource requirements are considerable;
- it is not good for evaluating cognitive errors;
- it does not produce explicit design recommendations; and
- large discrepancies exist between different analysts' estimates for the same task.

However, it is well known and generally acceptable for many applications. It is also scrutible, auditable and compatible with probabilistic risk analysis techniques, e.g. fault trees.

References:

Human Reliability Assessor's Guide (1988, ref.17)
Kirwan (1990, ref.13)

IDA - Influence Diagram Approach

Developed from the field of decision analysis, the inflence diagram approach may be taken to assess all elements of a human factors assessment. The influence diagram captures the model held by a group of experts regarding the dependence between the likelihood of success of a given operation and the factors which are perceived to have an affect.

The variables affecting the outcome are identified by a 'brainstorming' process, followed by refinement of the model and representation in the form of an influence diagram. Unlike other methods, IDA allows for interdependence between performance shaping factors. The structure of the diagram provides a qualitative indication of the factors which are most significant in influencing the outcome. Expert judgement may be applied at this stage to screen out error-producing conditions of minor significance.

The influence diagram may be converted into the fault tree format (and vice versa) and a computer program named DPL is available for this purpose.

Quantification is achieved by determining the 'balance of influence' at each level of the model. Several iterations may be required before consistency is accomplished throughout the model, although the results at this point are final and require no additional calibration.

The technique is flexible in terms of the level of decomposition that it can handle and has found application in the offshore industry.

However, IDA is potentially expensive in terms of the human resources involved as it relies heavily on input from a group of experts at all stages of the process.

References:

Human Reliability Assessor's Guide (1988, ref.17)
Kirwan & Ainsworth (1992, ref.15)

SCHEMA - System for Critical Human Error Management and Assessment

SCHEMA is an integrated framework of techniques for human factors assessment. The method has been implemented as a computer program called *THETA - Top-down Human Error and Task Analysis.* Techniques employed in the SCHEMA methodology are as follows:

- hierarchical task analysis for problem definition;
- human error analysis, which identifies action errors; checking errors; retrieval errors (information from displays, procedures, and memory); transmission errors (communication between individuals); and selection errors;
- qualitative screening;
- quantitative assessment, using SLIM; and
- suggested risk reduction strategy, implementation and monitoring of results.

References:

Embrey (1990, ref.18)

Task Analysis

Task analysis is primarily a means of problem definition, although elements of error identification may also be incorporated when conducting a study of human reliability. As well as describing the intended sequence of actions, such an application of task analysis indicates points at which errors may be discovered and then recovered.

Several forms of task analysis process are available, a selection of which are as follows.

HTA - Hierarchical Task Analysis

Operator actions are considered in terms of the goals the operator is trying to achieve. The result is a task model, indicating both the actions that need to be carried out (tasks and subtasks) and the sequences in which they are performed (plans).

TTA - Tabular Task Analysis

The information contained in the diagram obtained from HTA may be supplemented by recording data in tabular format using TTA. This form of task analysis is particularly useful for dynamic situations which involve a considerable amount of decision-making.

Sequential Task Analysis

This form of task analysis examines operator actions as they occur in chronological order. The technique is most suitable for proceduralised tasks, although in practice hierarchical aspects should also be considered when producing a task model.

Any number of techniques may be employed in order to perform a task analysis. A comprehensive review of the methods available, which includes examples of previous applications, is given by Kirwan & Ainsworth (1992, ref.15). This document stands out as the most useful source of information on task analysis, and presents case studies demonstrating previous applications in the offshore industry.

References:

Kirwan & Ainsworth (1992, ref.15)

Function Analysis

Function analysis is a method which identifies the roles of people in a system and their inter-relationship with equipment and subsystems and is applied in support of task analysis. Several techniques are available for performing function analysis, including link analysis which is described below.

Link Analysis

Link analysis is an ergonomic tool, principally of use in designing plant or control room layout. It identifies the physical elements of a system and the interfaces between them which are then represented as nodes and arcs, respectively on a *link diagram*. The length of each arc indicates its relative importance e.g. frequency of use, within the system. It is then analysed to indicate the optimal layout in terms of person-machine interfaces (operation of equipment) and person-person interfaces (communications). The technique has been applied offshore in the design of control rooms.

References:

Kirwan & Ainsworth (1992, ref.15)

Human HAZOP (Hazard and Operability) Study

The classic HAZOP approach has been adapted to identify the potential for human failures arising from deviations from intended sequences of actions. Human HAZOP techniques systematically consider deviations from a set of keywords at each stage of a task model, documented procedure, or work programme. Several techniques exist, each with a set of keywords tailored for specific applications. Examples of these include: *Driller's HAZOP; Operators' HAZOP;* and *PHECA - Potential Human Error Cause Analysis.*

References:

Willis, Deegan & Owens (1994, ref.19)
Kile & Magnussen (1994, ref.20)
Kirwan (1990, ref.13)
Kirwan & Ainsworth (1992, ref.15)

SHERPA - Systematic Human Error Reduction and Prediction Approach

SHERPA is a human error analysis technique. At each step in the task model, SHERPA is applied to identify systematically the potential for human error to occur. It is a structured question-answer routine and is available in the form of a computer program.

The technique is based on popular models of human error causation derived from psychological theory. Output is in the form of a human error analysis table which determines whether errors can be recovered immediately, at a later stage, or not at all, and attempts to link error reduction measures to causes.

References:

Kirwan (1990, ref.13)

PREDICT - Procedure to Review and Evaluate Dependency in Complex Technologies

The PREDICT approach is intended to identify seemingly bizarre human actions and where these actions violate assumptions about the independence of systems. HAZOP-based approaches are said to be limited in that they examine only what is happening within the process and therefore do not consider interaction between systems. The PREDICT approach differs from HAZOP in that it directs the analysis both inside and outside the process and places greater emphasis on identifying ways in which latent failures may reveal themselves. The approach features an extended set of guidewords which, although allowing a comprehensive analysis, may in practice be tedious to apply.

References:

Williams & Munley (1992, ref.16)

Sneak Analysis

Sneak analysis is a method for identifying latent failures in a system. Hence, when applied to human reliability assessment, it is particularly useful in identifying errors of commission. It is based on a systematic consideration of failure modes for each element of a process and identifies the ways in which the errors can cause the system to fail.

The method was developed for the analysis of electrical circuits and was subsequently applied in the development of computer software. It is generally applicable to any 'flow oriented' system and has been applied to identify human errors in process systems.

References:

Hahn, Blackman & Gertman (1991, ref.21)

Event Trees

Event trees are logic diagrams which illustrate how success or failure of specific events within a given sequence give rise to various outcomes. A specific failure is analysed to assess the opportunity for recovery at various stages of the scenario.

When applied to human factors assessment, the event tree represents the affect of human actions on the system (errors and recovery paths) and, through quantification, the likelihood of undesired consequences occurring. Variants of event trees include the *Operator Action Event Tree (OAET)*, the *Human Reliability Analysis Event Tree (HRAET)*, *Extended Operator Action Tree (EOAT)*, and the *Commission Event Tree (COMET)*.

In general, event trees have been found to be sufficient for simple models, but may not be appropriate for describing systems with interdependency.

References:

Kirwan & Ainsworth (1992, ref.15)

Task Hazard Identification

Task hazard identification is merely the combination of a human HAZOP with an Operator Action Event Tree. The results are employed as input to fault tree models.

SHARP - Systematic Human Action Reliability Procedure

SHARP is a qualitative screening method which is applied in HRA prior to full quantification. It filters out errors which are apparently incapable of affecting the system goal.

References:

Kirwan (1990, ref.13)

APJ - Absolute Probability Judgement

Otherwise known as 'direct numerical estimation', APJ is the most direct approach to quantifying HEPs. It is the simple use of engineering judgement to predict a human error probability for a given action. Where input from several experts is employed, a number of methods exist for compensating for biases to deliver a single value.

The approach has been applied to many industrial applications, including operations offshore. The Human Reliability Assessor's Guide presents a case study of APJ, applied in combination with THERP to assess the risk of drilling into a live (producing) well. The assessment was conducted at the design stage for a proposed platform.

References:

Human Reliability Assessor's Guide (1988, ref.17)

PC - Paired Comparisons

Paired comparisons is a method for generating human error probabilities based on engineering judgement. A panel of experts develops a scaled ranking of tasks in terms of relative likelihoods of error. Two or more tasks with known HEPs are used to calibrate the scale and hence determine HEPs for the remainder.

There is no evidence of any application to the offshore industry.

References:

Human Reliability Assessor's Guide (1988, ref.17)

HCR - Human Cognitive Reliability

HCR is a quantitative technique which provides cognitive error probabilities as a function of time elapsed since the onset of an incident. The method assumes that the likelihood of successful diagnosis increases with the time available to make a decision. HCR was developed in the nuclear industry as a means to evaluate the likelihood of control room operators taking the appropriate actions to control an incident and avoid escalation to a major accident.

The technique considers the effect of three performance shaping factors (operator experience, stress and interface quality) using one of a set of three time-reliability correlations. The correlation parameters are derived from nuclear power plant simulation data.

There is no evidence of any application to the offshore industry.

References:

Human Reliability Assessor's Guide (1988, ref.17)

HEART - Human Error Assessment and Reduction Technique

The HEART method was developed in the mid 1980's as a means of generating human error probabilities for use in probabilistic risk assessment at the design stage of a project. The method concentrates on evaluating the impact of a set of generic 'error producing conditions' which excludes factors which experience has shown do not contribute significantly to overall system reliability. Hence, some screening is inherent in the method.

The technique is based around a database of human error probabilities, which is a mixture of expert judgement and data from the ergonomics and psychology literature. The factors are well defined and specific, making them easy to measure.
Since much of the 'expertise' is incorporated within the method, it requires only one analyst to apply. The technique is therefore relatively quick and simple to use.

References:

Human Reliability Assessor's Guide (1988, ref.17)
Kirwan (1990, ref.13)

SLIM - Success Likelihood Index Methodology

The SLIM technique is a means of generating human error probabilities for use in probabilistic risk assessment. It employs a panel of experts to analyse a specific set of tasks and define their relative likelihood of success given the performance shaping factors (PSFs) affecting human reliability in those tasks. Reference tasks with known human error probabilities are included in the assessment so that the data may be calibrated.

The process may be summarised as follows:

- identify the performance shaping factors (PSFs) that affect the set of tasks;
- rate the tasks on the PSFs;
- apply weightings to the PSFs according to their relative importance on affecting the likelihood of success;

- evaluate the success likelihood index (SLI) for each task; and
- transform the SLIs to HEPs.

The SLIM approach is comprised of two modules. The first is called *MAUD (Multi Attribute Utility Decomposition)* - a computer application which elicits the judgement of several experts and then resolves ambiguities and biases between the inputs. The second module, *SARAH (Systematic Approach to the Reliability of Humans)* is the mathematical routine which calibrates the SLIs and converts them to HEPs.

The resource required to perform a SLIM assessment is relatively high. However, once an initial database has been established, the technique is relatively rapid to apply. It is highly scrutible and auditable, and has a good theoretical basis.

References:

Human Reliability Assessor's Guide (1988, ref.17)
Kirwan (1990, ref.13)

TESEO - Tecnica Empirica Stima Errori Operatori

The TESEO method is an empirical technique to estimate operators' errors, which was developed in Italy in the late 1970's, primarily for the process industries. The human error probability for a given task is predicted as a function of five factors which are assumed to be the major determinants of operator performance in any situation being considered.

TESEO is simple, quick and easy to use. It is also quite crude and both the model and data lack theoretical justification. There has been little publicised use of the technique and no evidence of it having been applied in the offshore industry.

References:

Human Reliability Assessor's Guide (1988, ref.17)
Atallah, Shah & Betti (1990, ref.22)

3.5 Human Factors in Offshore Activities

The literature has been searched for publications dealing specifically with human factors in three offshore activities:

- well control;
- service vessel operations; and
- crane operations.

3.5.1 Well Control

Principles behind well control are described in depth in Blowout Prevention (PETEX, 1980, ref.23). The topics include kick detection, mistakes in well control and kick control for offshore operations.

There are numerous publications on current best practice and human factors issues in safe drilling. A selection of these are Wand & Rasmus (1994, ref.24), Bamford & Wang (1994, ref.25), and the series of articles on Blowout Control currently being published in *World Oil.*

3.5.2 Service Vessel Operations

For service vessels, Jolly & Woodall-Mason (1994, ref.26) describe how incident investigation and analysis was used to improve safety through changes to hardware, procedures and organisation. Gibson (1992, ref.27) includes a section on emergency duties as part of a comprehensive description of supply vessel operations.

3.5.3 Crane Operations

Human factors issues in crane operations did not feature in any of the literature surveyed.

3.6 Accident and Incident Data

Until recently, the Department of Energy published an annual report, also known as *The Brown Book* (ref.28), which contained statistics for "all accidents and dangerous occurrences on or near installations and pipeline works or on attendant vessels in the course of any operation in connection with an installation in the UKCS". The data are coarsely divided across eleven broad categories, including Drilling, Boats and Cranes. The statistics pertain only to major incidents (deaths, serious accidents and dangerous occurrences) and provide no indication of the impact of human factors.

In the wake of the Piper Alpha disaster, the responsibility for safety in the UKCS was transferred to the Health and Safety Executive, Offshore Safety Division (HSE-OSD). Accident statistics ceased to be published in *The Brown Book* in 1991. The most recent data are the 1993 Offshore Accident and Incident Statistics, published by HSE-OSD in report number OTO-94-010 (ref.29). Incidents are recorded by severity, by operation, and by broad incident type. Again, the data are not refined enough to specify the human contribution.

The OREDA handbook (ref.30) contains offshore reliability data collated from the experience of operators in the Adriatic Sea, and the UK and Norwegian sectors of the North Sea. The data are recorded according to the item of equipment in which failure occurred. Similarly, WOAD (ref.31) is a database of worldwide offshore accident statistics covering the period 1970-1991. Again, the data do not indicate the contribution of human error to failure rates.

Ynnesdal & Bentsen (1994, ref.32) introduce *Synergy,* a pilot scheme for registration and analysis of Norwegian offshore incidents affecting health, safety and the environment. Waterfall *et alia* (1994, ref.8) present an approach to incident investigation and analysis which is aimed at monitoring the performance of safety management systems. It incorporates the TRIPOD theory to record human and organisational factors contributing to dangerous incidents.

There has been little effort in the UK offshore industry to collate human reliability data for any of its operations. The offshore risk assessment culture is still geared up to hardware-based reliability data. Safety cases have, in general, been submitted on the basis that failure data have human error inherent within them. Rather than examining human factors as the cause of incidents, the emphasis has been on considering the impact of human factors in response, i.e. from the potential escalation of incidents through to full and safe evacuation.

Although there is as yet no database in the public domain, there is evidence to suggest that human error data collection has begun in parts of the oil and gas industry, e.g. see ref.33.

Data for Drilling Operations

Some incident and accident statistics are provided by Baker (1992, ref.34) in a review of trends in drilling accident causation and risk reduction. Kick frequency data is presented in a recent article by Aarestad (1994, ref.35) which describes a Norwegian initiative for information and data exchange.

The Oil Industry International Exploration and Production Forum (1992, ref.36) Hydrocarbon Leak and Ignition Database contains an entire appendix on blowout frequency. Approximately 10% of wells in the database are located in Europe, i.e. UK, Norway, the Netherlands and Denmark.

Data for Service Vessel Operations

The performance of attendant vessels in emergencies offshore is the subject of an Offshore Technology Report OTH 87 274 (ref.37). The report examines the availability and capability of attendant vessels in providing emergency services based on a review of worldwide data. It also provides details of several evacuation incidents.

Lloyds Casualty Reports are renowned as a frequent and accurate source of information on incidents involving service vessels, e.g. impacts with rigs.

Data for Crane Operations

SINTEF (1989, ref.38) presents a method to assess the probability of dropped objects causing damage to subsea facilities. As part of this method, estimates of drop probability are established on the basis of past accident reports and expert judgement. Actual data are drawn mainly from the UK sector from sources such as *The Brown Book* (ref.28). The data are general (average over a large number of platforms) and provide no indication of the contribution of human error.

4.0 PROJECTS IN PROGRESS AND FORTHCOMING EVENTS

While researching the latest developments in human factors in offshore operations, several projects and conferences have been identified as potential sources of future information. These are included in the review as they are likely to represent the 'state of the art', even though no reports or proceedings are yet available.

The Robert Gordon University (RGU), Aberdeen is conducting several human factors projects for the offshore industry, the results of which will be published by HSE. The topics of these studies include analysing stress in survival course trainees; application of information technology to training; and risk perception in offshore workers. RGU has organised a conference "Understanding Risk Perception", Aberdeen, February 2nd 1995, where the findings of the study will be presented.

HSE continues to fund studies by the Department of Experimental Psychology, Oxford University into human factors, shift work and alertness in the offshore oil industry. Other human factors projects commissioned by HSE include a human factors analysis of drilling control (report at approval stage) and a study on physical selection for rescue craft crew.

Conferences recently organised by IBC Technical Services Limited include "Task Analysis for Industry", London, December 6th 1994, and "Drilling Technology Conference", November 24th 1994.

Incident and Accident Data

Incident data collection is an increasingly important issue in the UK. The HSE is currently in the process of amalgamating incident data from all industries into a single database and is keen to extend industry's obligations for incident reporting to cover 'near-misses' as well as 'major incidents'. In the offshore industry, the role of the UKOOA/HSE Failure Rate Data working group includes human error data but at present the group is focussing on hydrocarbon equipment leak data.

5.0 CURRENT APPLICATIONS OF TECHNIQUES

There is evidence to suggest that the qualitative and pragmatic methods of task observation and analysis have found some application in the offshore industry, though their use is by no means widespread. A criticism of these techniques is that although they indicate where deficiencies in human factors may have an adverse influence on the safe execution of tasks, they do not provide sufficient information to effectively address the problems identified. All too often, results indicate a need for more training, better procedures, greater competence, etc., but are not specific in terms of the *level* of improvement that would be considered sufficient.

Other, fundamental criticisms of current techniques include:

- several techniques are based on models of human failure that are yet to be validated; and
- with the apparent exception of the Influence Diagram Approach, techniques generally model performance shaping factors as independent, when in fact this may not be the case.

To gain acceptance, techniques must demonstrate the benefits of introducing change and that such measures will prove to be cost-effective. However, as Atallah, Shah & Betti (1990, ref.22) points out, no studies are available to show the link between performance shaping factor modification and reduction in human error probability. This makes it difficult to perform meaningful cost-benefit analysis.

As described above, there is a general lack of data on human error probabilities in the public domain. This may be attributed to:

- the 'denominator problem', i.e. estimating the number of opportunities for errors to occur in real tasks;
- confidentiality and unwillingness to publish data relating to poor performance; and
- lack of awareness of the usefulness of data collection.

However, regulatory bodies are taking a keener interest in the reporting of incidents and of the human factors contributing to the causes. The Norwegian Petroleum Directorate is already actively addressing this problem in the Norwegian offshore industry. In the UK, HSE is also eager for improved reporting of incidents, although at present, apart from major incidents (deaths, serious accidents and dangerous occurrences), incident data is provided mostly on a voluntary basis.

Other potential sources of human error probabilities are simulator data and lab-based studies. However, these data are obtained in artificial environments, so their applicability to real situations is questionable.

It may also be possible to translate human error data from other industries. Potential sources include the nuclear industry and the Gulf of Mexico offshore industry.

Due, in part, to the paucity of human reliability data, several of the techniques featured in the review have been developed to generate human error probabilities (HEPs) as input to quantitative risk assessment (QRA). These methods are generally perceived as too subjective and not entirely appropriate in meeting the data requirements of QRA. They have found little application in the UK offshore industry and so, in the absence of any 'hard' data, there has been a general reluctance to perform quantitative analyses.

6.0 CONCLUSIONS

The literature review has covered a broad subject area and features much of the most current information available. It has focussed on identifying references to techniques which may be used to assess the impact of human factors on the safety of offshore activities. Sources of offshore incident and accident data have been examined, though it has been discovered that these seldom provide information concerning the contribution of human failure.

There has been an apparent reluctance within the UK offshore industry to perform human factors assessments. This may be attributed to a number of factors:

1. human reliability data specific to offshore activities are scarce;

2. as a consequence, quantitative assessment relies heavily on expert judgement and is therefore perceived as time consuming, subjective and difficult to validate;

3. in terms of practical risk management, results have proved of little use in improving the control of hazards; and

4. there is an apparent lack of validation, theoretical or otherwise, for techniques in general.

TABLE 1. ORGANISATIONS CONTACTED

	Establishment	Contact Name	Address/ Phone	Comments
	IBC Technical Services Ltd	Sarah Ashmore	Gilmoora House, 57-61 Mortimer Street, London, W1N 7TD 071-637-4383	Organisers of *Task Analysis for Industry (6/12/94)*. First HF conference they've organised.
	IBC Technical Services Ltd	Oil & Gas Div. Helen Smith	Gilmoora House, 57-61 Mortimer Street, London, W1N 7TD 071-637-4383	Organisers of *Drilling Technology Conference* (24/11/94). Also: *Offshore Drilling Technology.*
	BICS International Conferences	Owain Jenkins	Oil & Gas Section, City Headquarters, 1st Floor, Chandos House, 12-14 Berry Street, London, EC1V 0AQ. 071-336-7988 (direct line)	Organisers: *Incorporating Human Factors into Offshore Safety Cases.*
	University of Birmingham	Barry Kirwan	Human Factors Dept 021-414-4247 (direct line)	Helpful. Source of further contacts and references.
	Techword Services	Michael Wright	0442 257635	Publishers of Offshore Research Focus - HSE, OSO, Matsu funded research.
	Taylor & Francis		071-405-2237	Technical publishers renowned for their ergonomics series.
	Safety and Reliability Society	Charlie Farnell	Clayton House, 59 Piccadilly, Manchester, M1 2AQ Tel: 061-228-7824 Fax: 061-236-6977	Sent list of relevant SaRS Proceedings.
	Institute of Chemical Engineers	Helen Langham (Library)	Davis Building, 165-171 Railway Terrace, Rugby, CV21 3HQ Tel: 0788 578214 Fax: 0788 560833	Performed literature search of "human factors" - IChemE databases.
	HSE	Enquiries	Information Centre, Broad Lane, Sheffield, S3 7HQ. Phone: 0742-892345 Fax: 0742-892333	Compiled list of relevant publications
	HSE OSD	Chris Dykes	Aberdeen 0224-252500	Helpful. Source of information on well control.
	HSE OSD	Stephen Connelly	Bootle 051-951-4000	Concerned with UK offshore incident statistics and accident data.

TABLE 1. ORGANISATIONS CONTACTED

	Establishment	Contact Name	Address/ Phone	Comments
	HMSO		Publications Centre, PO Box 276, London, SW8 5DT. 071 873 0011	Sent list of relevant HMSO publications
	British Lending Library	Garth Frankland	Tel: 0937 546809	Document supply service

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
1	HSE	1989	Human Factors in Industrial Safety....An Examination of the Roles of Organisations, Jobs and Individuals in Industrial Safety and a Practical Guide to Control. 4th impression HS(G)48. {London: HMSO}	8 publications recommended for further reading	EQE
2	Engineering Council	1993	Guidelines on Risk Issues	Several other refs.	HZ
3	Wreathall,J.	1993	Human Factors and Process Safety. *International Conference and Exhibition on Safety, Health and Loss Prevention in the Oil, Chemical and Process Industries, Singapore, 15-19 Feb.* {London: Butterworth-Heinemann} p.82-91		EQE
4	Donald,I.J, Canter,D.V, Chalk,J.R, Hale,A.R, and Gerlings,P.	1991	Measuring Safety Culture and Attitudes. *First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	Questionnaire to assess safety culture and attitudes in organisations. Developed from UK steel & chemical industries. Based upon extensive review of organisational & HF literature. Correlation with safety record. 0 references	EQE
5	Embrey,D.E.	Oct 89	The Management of Risk Arising from Human Error. *Human Reliability in Nuclear Power.* {IBC Technical Services}	Preprint Discusses organisational conditions which can lead to system failures. Introduces an audit-based methodology for assessing organisational integrity. 0 references	SCH
6	Bellamy,L.J, and Geyer,T.A.W.	1992	Organisational Management and Human Factors in Quantified Risk Assessment, Report 1. HSE Contract Research Report No. 33/1992.		Ab.Uni
7	Harrison,P.I.	1992	Organisational, Management and Human Factors in Quantified Risk Assessment, Report 2. HSE Contract Research Report No. 34/1992.	Development of audit question set with a view to taking account of management factors in QRA. About 50 references	DIB

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
8	Waterfall,K.W, Tjeenk Willink,C.A, and Milne,D.J.	1994	Incident Investigation and Analysis for Exploration and Production Operations.*Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	0 references	EQE
9	Hudson,P.T.W, Primrose,M.J, and Edwards,C.	1994	Implementing Tripod-DELTA in a Major Contractor. *Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	Design Evaluation Tool for Accident Prevention. Establishes human error causes of incidents. Concentrates on latent failures. Implications of extending access to contractors 3 references	EQE
10	Hudson,P.T.W. *et alia.*	1991	Enhancing Safety in Drilling: Implementing TRIPOD in a Desert Drilling Operation. *First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	Essentially an organisational audit based on theory of accident causation. Paper describes theory, results of application in desert drilling operations and implementation experience. 4 references	EQE
11	Hudson,P.T.W. *et alia*	1991	Application of TRIPOD to Measure Latent Errors in North Sea Gas Platforms: Validity of Failure State Profiles. *First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	TRIPOD applied to gas prod'n platforms on Dutch CS. Analyses of 10 recent accidents were compared to failure state profiles generated from interviews to validate the TRIPOD technique. 3 references	EQE
12	DeJoy,D.	May 90	Toward a Comprehensive Human Factors Model of Workplace Accident Causation. *Professional Safety.* May 1990, p.11-16.	Describes a framework for comprehensive human factors assessment. Refers to models/ tools that could be incorporated. 38 references	DIB
13	Kirwan,B.	1990	Human Reliability Assessment. Chapter 28 of *Evaluation of Human Work.* (eds: Wilson,J.R, and Corlett,N.) {London: Taylor & Francis}	57 references	SCH

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
14	Hashemi,K.	1992	Human Factor Considerations in Safety Techniques and Management. *Seminar on The Practicalities and Realities of Human Factors in Offshore Safety, 30 Sept - 1 Oct, 1992.*	Preprint.	EQE
15	Kirwan,B, and Ainsworth,L.K. (editors)	1992	A Guide to Task Analysis {Taylor & Francis}	Principal book on task analysis	Ab.Uni
16	Williams,J.C, and Munley,G.A.	1992	Human Error Identification - a New Approach. *PSA/PRA, Safety and Risk Assessment, IBC, London, 3/4 December 1992.*	Preprint 44 references	DIB
17	Kirwan,B, Embrey,D.E, and Rea,K.	1988	The Human Reliability Assessors Guide. Report RTS 88/95. Compiled by Human Factors in Reliability Group (HFRG). Sponsored by National Centre of Systems Reliability (NCSR). {SRD, UKAEA, Culcheth, Cheshire}		ABR
18	Embrey,D.E.	Post 1990	Managing Human Error in the Offshore Oil and Gas Industries.	Conference paper (preprint?) 12 references	SCH
19	Willis,D, and Deegan,F.	1994	HAZOP of Procedural Operations.*Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	2 references	EQE
20	Kile,H, and Magnusson,T.	1994	Practical System for Identification of Potential Hazards and Performance of Risk Analysis in Oil and Gas Operating Environments: Norwegian Approach. *Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	8 references	EQE

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
21	Hahn,H.A, Blackman,H.S, and Gertman,D.I.	1991	Applying Sneak Analysis to the Identification of Human Errors of Commission. *Reliability Engineering and System Safety.* v33, p.289-300.	Sneak analysis to identify human error, demonstrated by nuclear industry case study. 4 references	SCH
22	Atallah,S, Shah,J.N, and Betti,M.	20/4/90	Reduction of LNG Operator Error and Equipment Failure Rates. {Chicago: Gas Research Institute} GRI Rep.No.90/0008	HEPs derived from incident records and generic data. Discusses problem of accounting for reduced HEPs in cost-benefit analysis. 4 references	WWC
23	PETEX	1980	Blowout Prevention, 3rd Edition	0 references	Ab.Uni
24	Wand,P.A, and Rasmus,J.C.	1994	An Integrated Approach to Minimizing Risk While Drilling. *Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	13 references on well control	EQE
25	Bamford,A.S, and Zhihua Wang	1994	Well Control Simulation Interfaced with Real Rig Equipment to Improve Training and Skills Validation. *Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	Well control training. Reports on system trials in laboratory. About to go on trial in the field. 5 references to well control simulation	EQE
26	Jolly,C.W, and Woodall-Mason,N.W.	1994	Safety in Cargo Handling. *Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	In response to a spate of incidents, a 'Business Process Analysis' was applied to reduce accident rate. Accident event trees assisted in identifying root causes of accidents, leading to improvements in hardware, procedures and organisation. 1 reference	EQE
27	Gibson,V.	1992	Supply Vessel Operations {Butterworth-Heinemann}	Functions of supply vessels, including ship handling; anchor handling; towing; emergency duties. 12 recommendations for further reading	Ab.City

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
28	Department of Energy, London	Annual Report	Development of the Oil & Gas Resources of the United Kingdom. "The Brown Book" {London: HMSO}	0 references	Ab.Uni
29	HSE Offshore Safety Division	1994	1993 Offshore Accident and Incident Statistics. OTO-94-010	Successor to "Brown Book". Incidents reported by severity (4 categories); operation (10 types) and broad incident type (17 categories). No indication of contribution of human error.	EQE
30	OREDA	1992	Offshore Reliability Data, 2nd Edition	6 references	EQE
31	WOAD	1992	Worldwide Offshore Accident Databank.	Offshore accident statistics covering period 1970-91. Contribution of human errors not specified	EQE
32	Ynnesdal,H, and Bentsen,B.A.	1994	Information System for Exchange of Experiences from Accidents and Incidents Among Oil Companies and Contractors.*Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	"Synergy" pilot scheme: registration and analysis of events affecting health, safety and environment. Norwegian experience. 2 references	EQE
33	Azambre,J.	1991	Accident Analysis: A Tool for Safety Management. *First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	Total's Occupational Accident Analysis and Reporting (OCAAR) System. Identifies and records root causes of accidents, including human factors, procedural factors, technical defects, etc. 0 references	EQE
34	Baker, Bob	1992	Drilling System Developments Reduce Risks Offshore. *The Impact of Technical Developments on Safety Cases. London, 19 Mar.* {IBC Technical Services}	One of 9 papers. Review of trends in drilling accident causation and risk reduction methods. Some incident and accident statistics.	RGU

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
35	Aarestad,T.V.	1994	Challenges in Planning, Drilling and Testing HPHT Wells. *Offshore International*	Norwegian initiative for information and data exchange. Objectives: detail problems known to have occurred; investigate reason for deficiencies (including human factors); safer & more efficient drilling thru equip technology & procedures. Presents some kick frequency data. 1 reference.	EQE
36	Oil Industry International Exploration & Production Forum	May 92	Hydrocarbon Leak and Ignition Database. Report11.4/180	Contains entire appendix on blowout frequency. Approximately 10% of wells in database are European, i.e. UK, Norway, the Netherlands and Denmark. Data are divided between well control problems and uncontrolled blowouts.	EQE
37	Offshore Technology Report	1987	The Performance of Attendant Vessels in Emergencies Offshore. OTH 87 274 {London: HMSO}		EQE
38	SINTEF	22/9/89	Dropped Objects on Subsea Installations	30 references	EQE
	-	1991	*First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	2 volumes Several papers of interest - in addition to those described above, proceedings contain several papers on HS&E auditing	EQE
	-	1994	*Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	2 volumes 9 papers of interest	EQE
	-	1993	*International Conference and Exhibition on Safety, Health and Loss Prevention in the Oil, Chemical and Process Industries, Singapore, 15-19 Feb.* {London: Butterworth-Heinemann}	One paper of interest - Wreathall (1993)	EQE

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
	Amato,F.S, Resweber,L.R, and Jones,M.A.	1991	Facilities Design Focus for Health, Safety, and Environment: Compliance and Compliance Monitoring. *First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	Paper illustrating Shell's new approach to design (applied to Shell's first TLP). Human factors engineering introduced at design stage. 0 references	EQE
	Bailey,R.W.	1982	Human Performance Engineering: A Guide for Systems Designers {Prentice Hall} ISBN 0-1344-5332-4	Basic textbook pooling together the experience of human factors department of Bell Laboratories. HF explained in simple terms with many examples. Briefly describes role of function analysis and task analysis in defining human performance requirements and allocation of work in system design. Practical advice on collecting information (questionnaires, interviews, etc)	Ab.Uni
	Bainbridge,L, Lenior,T.M.J, and van der Schaaf,T.W. (eds)	1993	Cognitive Processes in Complex Tasks. Special Edition of *Ergonomics*, v36, n11.	Recent collection of 16 papers devoted to cognitive human factors (operating personnel)	Ab.Uni
	Battmann,W, and Klumb,P.	1991	Behavioural Economics and Safety. *First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	Conditions that produce errors of violation explained in 'behavioural economics' terms: 1) unclear or conflicting constraints; 2) delayed or missing feedback; 3) conflicts between high-level and low-level safety commitments. 17 references	EQE
	Bourne,A.J, Edwards,G.T, Hunns,D.M, Poulter,D.R, and Watson,I.A.	Jan 81	Defences Against Common-Mode Failures in Redundancy Systems. A Guide for Management, Designers and Operators. SRD R 196 {London: HMSO}	Qualitative guidance on design and operation of redundancy systems to provide defences against common mode failure. 4 references	EQE

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
	Chiles,W.E.	May 92	Chiles' Tank Analysis Improves Safety, Quality. *Drilling Contractor.*	Describes how task analysis has been applied by Chiles Offshore Corp. 0 references	SJL
	CONCAWE	Dec 93	Catalogue of CONCAWE Special Interest Reports	Rep.No.93/60. Nothing except 88/56 (see below).	EQE
	CONCAWE	Dec 93	Catalogue of CONCAWE Reports	Rep.No.3/93. Nothing	EQE
	CONCAWE	Jul 88	Quantified Risk Assessment	Rep.No.88/56. General discussion of HF in QRA. 0 references	EQE
	Cracknell,D.	1993	Audit and the Living Safety Case. *Offshore Safety Cases: The Living Documents - Where Next? London, 1-2 Dec.* {IBC Technical Services}	One of 13 papers. British Gas E&P's philosophy, methodology and programme for conducting safety audits.	RGU
	Edwards,G.T, and Watson,I.A.	Jul 79	A Study of Common Mode Failures. SRD R 146 {London: HMSO}	Operator error discussed in the context of common mode failure.	EQE
	Fitzgerald,B.P, Green,M.D, Penington,J and Smith,A.J.		A Human Factors Approach to the Effective Design of Evacuation Systems. *Loss Prevention Bulletin*, n.97 {Rugby: IChemE}, p.13-22.	Discusses human behaviour in emergencies and issues to be considered in design of evacuation systems. Also published in "Piper Alpha: Lessons for Life-Cycle Safety Management".	EQE (SJL)
	Flak,L.H, Wright,J.W, and Tuppen,J.A.	Dec 93	Blowout Control: Response, Intervention and Management. Part 2 - Logistics. *World Oil*	Access to special services and equipment & materials through pre-contracting, communication and transport. 1 reference	RJT
	Flak,L.H, and Gloger,D.	Jul 94	Blowout Control: Response, Intervention and Management. Part 8 - Case History: Control of an Offshore HPHT Underground Blowout. *World Oil*	Case history of a successful blowout kill	RJT
	Flak,L.H, and Tarr,B.A.	May 94	Blowout Control: Response, Intervention and Management. Part 6 - Underground Blowouts Between Subsurface Intervals and can Result in a Significant Escalation Threat if not Recognised Quickly and Controlled Correctly. *World Oil*	Basic info on how to recognise an underground blowout and methods that can be used to regain well control. 4 references	RJT

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
	Flak,L.H, Wright,J.W, and Ely,J.	Nov 93	Blowout Control: Response, Intervention and Management. Part I - Strategy and Planning. *World Oil*	Proactive management contingency planning - roles & responsibilities. 1 reference	RJT
	Grepinet,M, and Flak,L.H.	Jun 94	Blowout Control: Response, Intervention and Management. Part 7 - After Underground Blowouts, Shallow Gas Blowouts are the Second Most Common Type of Blowout and the Most Common Type of Surface Blowout. *World Oil*	Dangers particular to shallow gas; selection of rigs; choice of diverters; preferred approach; special training needs; disaster mitigation requirements. 15 references	RJT
	Hashemi,K.	1991	An Integrated Approach to a Safety Case. *Conference in Human Factors in Offshore Safety, Aberdeen, 23/24 April, 1991.*	Preprint Integration of SMS within QMS. 0 references	DIB
	Jones,A.	1991	Human Factors and Command Control - Emergency Planning. *3rd North Sea Safety Conference, London, 30/10/91.*	Organisers: Technology Forum, HSE. No model. Some terminology; general discussion of contingency planning. 0 references	RJT
	Keen,E.	1980	Blowout Prevention, Short Course Manual	PETEX course. 0 references	Ab.Uni
	Kirwan,B, and James,N.	1989	The Development of a Human Reliability Assessment System for the Management of Human Error in Complex Systems. *Proceedings of Reliability '89.* Vol.2, Paper 5A/2	BNFL Human Reliability Management System (HRMS). Integrated framework. Modules for task analysis; human error identification; quantification; documentation and QA.	EQE
	Marine Accident Investigation Branch, DoT.	1992	Annual Report. {London, HMSO}	Merchant shipping accident statistics	WFV

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
	Pennycook,W.A, and Danz-Reece,M.E.	1994	Practical Examples of Human Error Analysis in Operations. *Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	Analysis tool developed for operating personnel to reduce potential for human errors in their work. Systematically identifies factors that contribute to errors so personnel may address fundamental causes. Overview; test applications; lessons learnt; common problems identified; benefits. 8 references	EQE
	Pertamina,R. *et alia*	1991	Personal, Place, and Time Characteristics of Offshore Accidents in Five Oil Companies Operating in Indonesis. *First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	Presents some coarse statistics to demonstrate broad trends. Accident records analysed in terms of 20 personal, time and place variables. 1 reference	EQE
	Price,H.E, Maisano,R.E, and Van Cott,H.P.	Jun 82	The Allocation of Functions in Man-Machine Systems: A Perspective and Literature Review. NUREG/CR-2623 {Oak Ridge National Lab.}	Context: Nuclear power plant control rooms. Criteria for assessing design proposals for automated systems. Method of evaluating impact on safety.	SCH
	Raman,J.R, Gargett,A, and Warner,D.C.	1991	Application of HAZOP Techniques for Maintenance Safety on Offshore Installations. *First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	Framework for applying batch HAZOP techniques to offshore (focus on topside processes) maintenance procedures. Suggests guidewords specific to PTW; preparation for maintenance; maintenance activity; handback & restart. Proposed use - design of maintenance manuals, procedures. 4 references	EQE
	Recht,J.L.	1965?	Systems Safety Analysis - A Modern Approach to Safety Problems. Collection of articles.	Reprinted from *National Safety News*. {National Safety Council, Chicago, Illinois} Includes description of THERP 10 references, all 1962-1965.	DIB

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
	Rike,J.L, Whitman,D.L, Rike,E.R, and Hardin,L.R.	Nov 93	Why Workover and Drilling Well Control Needs Differ. *World Oil*	Differences in well control between completion/workover and drilling operations	RJT
	Salvato,S.J, and Flak,L.H.	Jan 94	Blowout Control: Response, Intervention and Management. Part 3 - Insurance. *World Oil*	Control-of-well insurance coverage - policies available & what can be covered. 3 refs.	RJT
	Salvendy,G.(ed)	1987	Handbook of Human Factors {New York: Wiley}	66 chapters written by 103 people gathering information from 3850 references.	Ab.Uni
	Senders,J.W, and Moray,N.P.	1991	Human Error: Cause, Prediction and Reduction {Lawrence Erlbaum Assoc} ISBN 0-89859-593-3	Account of how human error as a subject has evolved. Philosophical. Taxonomies. 15 references	Ab.Uni
	Shrimpton,M, and Storey,K.	1994	Human Factors and Health and Safety in Offshore Oil Operations: Relationships and Management Options.*Second International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Jakarta, 25-27 Jan.* {Society of Petroleum Engineers}	Review of some Canadian, European and Australian research into impact of organisational level human factors. 16 references	EQE
	Smestad,P, Rygg,O.B, and Wright,J.W.	Apr 94	Blowout Control: Response, Intervention and Management. Part 5 - Hydraulics Modelling. *World Oil*	Matching known downhole well info with surface flow characteristics allows selection of most efficient kill method.	RJT
	Smith,A.J.	1991	The Importance of Safety Management Systems within Formal Safety Assessments. *Offshore Safety Cases: Preparation and Implementation. London, 18-19 Nov.* {IBC Technical Services}	One of 16 papers. Management and organisational influences in maintenance of adequate safety standards. SMS auditing and implementation.	RGU

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
	Sutherland,V.J.	1991	Occupational Stress and Accidents Offshore. *First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	One year survey of offshore personnel to: examine sources of stress; examine links between stress, personal factors and previous accident involvement; investigate individual differences as a function of occupational status, type, size & location of installation. 13 references	EQE
	Wright,J.W, Woodruff,J.F, and Thompson,D.	Mar 94	Blowout Control: Response, Intervention and Management. Part 4 - Documented Blowout Contingency Plans. *World Oil*	Emergency management & response system to reduce vulnerability to blowout. 1 ref.	RJT
	Young,D.R.	1991	Psychological Factors in Safety Performance. *First International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, The Hague, 11-14 Nov.* {Society of Petroleum Engineers}	Discusses psychological characteristics of both individuals and groups in context of health and safety offshore. 4 references	EQE

TABLE 2A. PUBLICATIONS OBTAINED AND REVIEWED BY EQE

LEGEND - SOURCES

Ab.City	Aberdeen City Library
Ab.Uni	Aberdeen University Library
ABR	Alan Reeves, EQE Warrington.
AL	Andrew Lidstone, EQE Warrington.
DIB	Derrick Bentham, EQE Aberdeen
EQE	EQE Aberdeen Office Library
HZ	Dr Zerkani, Aberdeen University
MGH	Martin Holley, EQE Aberdeen
RGU	Robert Gordon University Central Library
RJT	Rod Travis, EQE Aberdeen
SCH	Suzanne Hill, EQE Warrington Office Library.
SJL	Steve Lewis, EQE Aberdeen
WFV	Bill Venn, EQE Aberdeen
WWC	Bill Cohea, EQE Houston

TABLE 2B. PUBLICATIONS OBTAINED BY EQE - NOT REVIEWED

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
	-	Oct 1975	Reactor Safety Study: An Assessment of Accident Risks in US Commercial Nuclear Power Plants. {Nuclear Regulatory Commission}. Report No. WASH-1400.		SJL1
	-	1989	*Proceedings of Reliability '89.*	Other papers of interest?	EQE
	-	Sept 1986	Proceedings of *Human Reliability Assessment*, London, 9-10 Sept 1986. {IBC Technical Services Limited}	Several papers of interest	SJL2
	-	1991	*Technology Assessment and Research Program for Offshore Minerals Operations, 1991 Report.* {US Minerals Management Service}.	OCS Study MMS 91-0057	WWC
	Ball,P, *et alia*	Feb 1985		Qualitative ergonomic guidelines intended for use by management. Essentially an audit/ design checklist.	SJL2
	Bea,R.G, and Moore,W.H.	1991	Management of Human Error in Operations of Offshore Platforms. *Technology Assessment and Research Program for Offshore Minerals Operations, 1991 Report.* {US Minerals Management Service}.	OCS Study MMS 91-0057	WWC
	Bea,R.G, and Moore,W.H.	1994	Reliability Based Evaluations of Human and Organizational Errors in Reassessment and Requalification of Platforms. *International Offshore Mechanics and Arctic Engineering Conference, Safety and Reliability Symposium, Houston, Feb 1994.*		WWC
	Bell,B.J, and Swain,A.D.	1983	A Procedure for Conducting a Human-Reliability Analysis for Nuclear Power Plants. NUREG/CR--2254.		SJL3

TABLE 2B. PUBLICATIONS OBTAINED BY EQE - NOT REVIEWED

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
	Drury,C.G, Paramore,B, Van Cott,H.P, Grey,S.M, and Corlett,E.N.	1987	Task Analyis. In *Handbook of Human Factors*, Salvendy,G.(ed), p.370-401.		Ab.Uni
	HSE	1983	Sizewell B: A Review by HM Nuclear Installations Inspectorat. Report NII 01, Supplement 13: Human Factors		SJL2
	Hunns,D.M, and Daniels,B.K.	July 1980	The Method of Paired Comparisons. *6th Advances in Reliability Technology Symposium, University of Bradford.* {National Centre of Systems Reliability, UKAEA, Warrington} NCSR R23 Vol.1, p.31-71.		SJL1
	Hunns,D.M.	April 1982	Psychology of Communications. *7th Advances in Reliability Technology Symposium, University of Bradford.* {National Centre of Systems Reliability, UKAEA, Warrington}.		SJL1
	Kirwan,B, Martin,B, Rycraft,H, and Smith,A.	Apr 1990	Human Error Data Collection and Data Generation. *11th Advances in Reliability Technology Symposium, Liverpool, April 1990.* Preprint		SJL2
	Laughery,K.R,Sr. and Laughery,K.R, Jr.	1987	Analytic Techniques for Function Analysis. In *Handbook of Human Factors*, Salvendy,G.(ed), p.329-354.		Ab.Uni
	Livingston,A.D, Wright,M.S, and Embrey,D.E.	?	The Application of Task Analysis and Human Error Analysis to the Development of Operating Instructions in a Batch Chemical Process Plant.	Authors from Human Reliability Associates Ltd. Preprint, p13 & Fig 1 missing.	DIB
	McCormick,E.J, and Sanders,M.S.	1982	Human Factors in Engineering and Design. Fifth Edition. {McGraw Hill} ISBN 0-0704-4902-3	Classic text on ergonomics for man-machine interface in design.	Ab.Uni

TABLE 2B. PUBLICATIONS OBTAINED BY EQE - NOT REVIEWED

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
	Miller,D.P, and Swain,A.D.	1987	Human Error and Human Reliability. In *Handbook of Human Factors*, Salvendy,G.(ed), p.235-250.		Ab.Uni
	Moore,W.H, and Bea,R.G.	1993	Human Organizational Error in Operations of Marine Systems: Occidental Piper Alpha. *Offshore Mech & Arctic Eng Conf, Glasgow, 20-24 June - Volume II, Safety and Reliability.* p.21-29	3-28-D-002	WWC
	Moore,W.H, Bea,R.G, and Roberts,K.H.	1993	Improving the Management of Human and Organizational Errors (HOE) in Tanker Operations. *Ship Structures Symposium, Arlington, Virginia, Nov 16/17.*	3-28-D-002 Conference sponsors: Soc of Naval Architects & Marine Engs; The Ship Structure Committee.	WWC
	Reason,J.		Catastrophic Combinations of Trivial Errors. In *Psychology of Occupational Safety and Accidents* (Eds: Cox,T, Cox,S, and MacKay). Preprint - May 1985		SJL1
	Reason,J.T.	1990	Human Error {Cambridge University Press}	Referred to by Ref.9	Ab.Uni
	Samantha,P.K, O'Brien,J.N, and Morrison,H.W.	1985	Multiple-Sequential Failure Model: Evaluation of and Procedures for Human Error Dependency. NUREG/CR--3837		SJL3
	Sayers,B.A.(ed)	1988	Human Factors and Decision Making: Their Influences on Safety and Reliability. *Safety and Reliability Society Symposium, Altrincham.* {Chapman & Hall}	Several papers of interest	Ab.Uni
	Simiu,E. (Editor)	Apr 92	*Reliability of Offshore Operations: Proceedings of an International Workshop.*	NIST Special Publication 833	WWC
	Swain,A.D, and Guttmann,H.E.	1983	Handbook of Reliability Analysis with Emphasis on Nuclear Power Plant Applications {Sandia Labs, Albuquerque, NM}. NUREG/CR-1278.		SJL1

TABLE 2B. PUBLICATIONS OBTAINED BY EQE - NOT REVIEWED

Ref. No.	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	Summary/Comments	Source
	Tepas,D.I, and Monk,T.H.	1987	Work Schedules. In *Handbook of Human Factors*, Salvendy,G.(ed), p.819-843.		Ab.Uni
	Waters,T.L.	1988	Human Reliability Analysis Methods. *International Approach to Nuclear Safety (after Three Mile Island and Chernobyl)*, Blackpool, 8-10 June 1988. Preprint.		SJL2
	White,R.F.	Mar 1984	A Suggested Method for the Treatment of Human Error in the Assessment of Major Hazards. SRD R 254. {UKAEA, Warrington}		SJL2
	Whitfield,D.	1986	Meeting Report: *International Topical Meeting on Advances in Human Factors in Nuclear Power Stations, Knoxville TN, 21-24 April 1986.*	Summary of presentations giving overview of human factors R&D worldwide (1986)	SJL1
	Williams,J.C.	1988	A Data-Based Method for Assessing and Reducing Human Error to Improve Operational Performance. *IEEE 4th Conference on Human Factors in Power Plants, Monterey, California, 6-9 June 1988.*	"... The HEART Methodology Explained"	DIB

TABLE 2B. PUBLICATIONS OBTAINED BY EQE - NOT REVIEWED

LEGEND - SOURCES

Ab.City	Aberdeen City Library
Ab.Uni	Aberdeen University Library
ABR	Alan Reeves, EQE Warrington.
AL	Andrew Lidstone, EQE Warrington.
DIB	Derrick Bentham, EQE Aberdeen
EQE	EQE Aberdeen Office Library
HZ	Dr Zerkani, Aberdeen University
MGH	Martin Holley, EQE Aberdeen
RGU	Robert Gordon University Central Library
RJT	Rod Travis, EQE Aberdeen
SCH	Suzanne Hill, EQE Warrington Office Library.
SJL	Steve Lewis, EQE Aberdeen
WFV	Bill Venn, EQE Aberdeen
WWC	Bill Cohea, EQE Houston

TABLE 3. MATERIAL IDENTIFIED BUT NOT OBTAINED DURING STUDY

	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	ISBN Number
*	-	1992	*The Practicalities and Realities of Human Factors in Offshore Safety, Aberdeen, 30 Sep. - 1 Oct.* {Business Seminars International}	
	-	Mar 1994	*Incorporating Human Factors into Offshore Safety Cases.* {BICS International Conferences}	
	-	1992	*Major Hazards Onshore and Offshore, Manchester, 20-22 Oct.* {IChemE Symposium Series No.130}	0-8529-5283-X
*	-	1990	*Reliability Engineering and System Safety*, v29, n3.	
	ACSNI	1993	Advisory Committee on Safety of Nuclear Installations: Study Group on Human Factors {HMSO}	
*	AIChE	1994	Guidelines for Preventing Human Error in Process Safety {AIChE}	0-8169-0461-8
	AIChE	1994	Integrating Human Factors into Process Safety Management (AIChE}	
*	Arizono,N, *et alia*	1993	Crane Operation Support System. *R & D: Research and Development*, v43, n1, p47-50	
	Ball,P. (ed)	1991	The Guide to Reducing Human Error in Process Operations {HMSO}. Human Factors in Reliability Group. SRDA-R3	
	Bellamy,L.J, and Geyer,T.A.W.	1991	Incorporating Human Factors into Formal Safety Assessment: The Offshore Safety Case. *3rd BHR Group Ltd. Management and Engineering of FIre Safety and Loss Prevention Int. Conf, Aberdeen,18-20 Feb.* p.55-63	
	Bellamy,L.J, Kirwan,B, and Cox,R.A.	1986	Incorporating Human Reliability into Probabilistic Risk Assessment. *5th Int. Symp in Loss Prevention and Safety Promotion in the Process Industries.* {Societe de Chimie Industrie}	
	Bellamy,L.J.	Jul 85	How People's Behaviour Shapes Your Plant Operation. *Process Engineering.*	
*	Bodsburg,L.	1993	Comparative Study of Quantitative Models for Hardware, Software and Human Reliability Assessment. *Quality and Reliability Engineering International*, v9, n6, p.501-518	
	Cacciabue,P.C.	1993	Methodology of Human Factors Analysis for Systems Engineering. *Proc.1993 Int. Conf. on Systems, Man and Cybernetics, Le Touquet, France.* Part 1 (of 5). {IEEE}	

TABLE 3. MATERIAL IDENTIFIED BUT NOT OBTAINED DURING STUDY

	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	ISBN Number
*	Carey,M.S, and Bennett,G.R.	1992	Addressing Human Factors Throughout the Safety Lifecycle of an Installation. *Inst. Marine Eng. et al Offshore Safety: Protection of Life and the Environment Int. Conf, London*, 20,21 May. p.47-56	
	Comer,M.K, Seaver,D.A, Stillwell,W.G, and Gaddy,C.D.	1984	Generating Human Reliability Estimates Using Expert Judgement. USNRC Report NUREG/CR-3688. {Washington DC: USNRC}	
*	Comer,P.J, Fitt,J.S, and Ostebo,R.	1986	A Driller's HAZOP Method. *Society of Petroleum Engineers European Conference, London, Oct 86.* SPE 15867	
	Cox,R.F, and Walter,M.H. (editors)	1991	*Offshore Safety and Reliability.* Proceedings of Safety and Reliability Society Symposium, Sutton Coldfield, 18-19 Sept. {London: Elsevier}	1-8516-6708-3
	Cranfield & DNV	1982	Safety Shutdown Systems on Offshore Installations: A Joint Research Project Carried Out by Cranfield Institute of Technology and Det Norske Veritas. {Stavanger: Oljedirektoratet}	
	David,G.D.	1984	Ergonomic Design Could Promote Safer Drilling. *Oil and Gas Journal, December 10.* p.95-98, 103	
	Dhillon,B.S.	1990	Human Error Data Banks. *Microelectronics and Reliability*, v30, n5, p.963-971	
*	Drury,C.G.	1983	Task Analysis Methods in Industry. *Applied Ergonomics*, v14, p.19-28	
*	Eide,E, Hage,J.I, Burge,P.M, Jurgens,J, and Hughes,B.	1993	The Application of Slim-Hole Drilling Techniques to High-Temperature and High-Pressure Exploration Programs in the North Sea. *Proc. Soc. Pet. Eng. Annual Technology Conference and Exhibition, Houston.* Part 2 (of 5). p.259-268	
	Embrey,D.E, and Kirwan,B.	1983	A Comparative Evaluation Study of Three Subjective Human Reliability Qualification Techniques. *Proc. Ergonomics Soc. Conf. 1983.* Coombes,K. (Ed) {Taylor & Francis} p.137-141	
	Embrey,D.E.	1992	Managing Human Error in the Chemical Process Industry. *International Conference on Hazard Identification and Risk Analysis: Human Factors and Human Reliability in Process Safety.* {Center For Chemical Process Safety}. p.399-413	
	Etherton,J.J.(ed)	1986	Sources of Information for the Offshore Industry {Institute of Petroleum}	

TABLE 3. MATERIAL IDENTIFIED BUT NOT OBTAINED DURING STUDY

	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	ISBN Number
	Fitzgerald,B.P, Green,M.D, Penington,J, and Smith,A.J.	1991	A Human Factors Approach to the Effective Design of Evacuation Systems. *Loss Prevention Bulletin*, n97, p.13-22	
	Gertman,D.I, Blackman,H.S, Haney,L.N, Seidler,K.S, and Hahn,H.A.	1992	INTENT: A Method for Estimating Human Error Probabilities for Decision-Based Errors. *Reliability Engineering and System Safety*, v35, p.127-136.	
*	HSE	1990	Study Group on Human Factors First Report on Training and Related Matters	0-1188-5695-2
*	HSE	1993	Human Factors, Shift Work and Alertness in the Offshore Oil Industry. Offshore Technology Report OTH 92 389.	0-1188-2135-0
*	HSE	1991	Study Group on Human Factors Second Report: Human Reliability Assessment - A Critical Overview	0-1188-5695-2
*	Hudson,P.T.W, *et alia*	1994	Tripod Delta: Proactive Approach to Enhanced Safety. *Journal of Petroleum Technology*, v46, n1, p.58-62	
	Hudson,P.T.W. *et alia*	1994	Tripod DELTA: A Proactive Approach to Enhanced Safety. *Journal of Petroleum Technology.*	
*	Humphreys,P.	1993	Human Reliability Assessors Guide (Long Version). SRDA-R7 {AEA Technology, HF in Reliability Group}	
	IBC Conferences	1991-	Proceedings from 14 conferences	
*	IMechE	1991	*Safety Developments in the Offshore Oil and Gas Industry, Glasgow, 23-24 Apr.* {IMechE}	0-8529-8763-3
*	Jenkins,A.M, Brearley,S.A, and Stephens,P.	1991	Management At Risk. SRDA-R4 {AEA Technology}	0-8535-6362-4
*	Kirwan,B.	1987	Human Reliability Analysis of an Offshore Emergency Blowdown System. *Applied Ergonomics.* v18, n1, p.23-33	
*	Kirwan,B.	1992	Human Error Identification in Human Reliability Assessment. Part 1: Overview of Approaches. *Applied Ergonomics.*	

TABLE 3. MATERIAL IDENTIFIED BUT NOT OBTAINED DURING STUDY

	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	ISBN Number
	Price,M.	1988	Drilling Injury Concentrations on Modern Fixed Platforms and in Connection with Mechanised Drilling Equipment (Norwegian Offshore Drilling Operations, 1980-1986) {Rogaland Research Institute}. Report No. RF 22/88	8-2722-0161-5
	Rasmussen,J.	1982	Human Errors: A Taxonomy for Describing Human Malfunctions in Industrial Installations. *Journal of Occupational Accidents*, v4, n.2-4, p.311-333	
*	Reason,J.T.	1991	Disasters and Human Failures. *Psychological Aspects of Disasters.* Taylor,A, Lane,D, and Muir,H. (eds.) {British Psychological Society}	
	Roberts,K.H.	1990	Some Characteristics of High Reliability Organizations. *Organization Science*, v1, n2, p.160-177	
	Sanders,M.S, and McCormick,E.J.	1992	Human Factors in Engineering and Design, Ed.7 {McGraw Hill}	0-0711-2826-3
	Shanks,F.E, and Williams,K.R.	1993	Slim-Hole Exploration Requires Proper Technical Preparation. *Proc. Soc. Pet. Eng. Annual Technology Conference and Exhibition, Houston.* Part 2 (of 5). p.235-244	
	Shepherd,A.	1986	Issues in the Training of Process Operators. *International Journal of Industrial Ergonomics*, v1, 49-64.	
	Staples,L.J.	1993	Task Analysis Process for a New Reactor. *Proc 37th Annual Meeting of the Human Factors and Ergonomics Society, Seattle.* {Human Factors and Ergonomics Society Inc., Santa Monica} p.1024-1028	
	Sutherland,V.J, and Cooper,C.L.	1984	Occupational Stress in the Offshore Oil and Gas Industry. In *International Reviews of Ergonomics: Current Trends in Human Factors Research and Practice.* Volume 3, ed. D.J.Oborne {Taylor & Francis}	
	Tompkins,B.G, Watson,W.D, *et alia*	1982	Human Factors Affect Panel/Console Design for Offshore Facility. *Oil and Gas Journal*, v80, n32, p.147-152	
	Wardell,R.W.	1989	The Application of Ergonomics to Oilwell Drilling Rigs. *Proceedings of the Human Factors Association of Canada 22nd Annual Conference, Mississauga, Ontario, 26-29 Nov.* p.135-139	
	Watson,W.D, and Moore,P.	1993	Momentum Kill Procedure Can Quickly Control Blowouts. *Oil and Gas Journal*, v91, n35, p.74-77	

TABLE 3. MATERIAL IDENTIFIED BUT NOT OBTAINED DURING STUDY

	Author/ Establishment	Date	Title, *Journal/Conference*, {Publisher}	ISBN Number
	Price,M.	1988	Drilling Injury Concentrations on Modern Fixed Platforms and in Connection with Mechanised Drilling Equipment (Norwegian Offshore Drilling Operations, 1980-1986) {Rogaland Research Institute}. Report No. RF 22/88	8-2722-0161-5
	Rasmussen,J.	1982	Human Errors: A Taxonomy for Describing Human Malfunctions in Industrial Installations. *Journal of Occupational Accidents*, v4, n.2-4, p.311-333	
*	Reason,J.T.	1991	Disasters and Human Failures. *Psychological Aspects of Disasters.* Taylor,A, Lane,D, and Muir,H. (eds.) {British Psychological Society}	
	Roberts,K.H.	1990	Some Characteristics of High Reliability Organizations. *Organization Science*, v1, n2, p.160-177	
	Sanders,M.S, and McCormick,E.J.	1992	Human Factors in Engineering and Design, Ed.7 {McGraw Hill}	0-0711-2826-3
	Shanks,F.E, and Williams,K.R.	1993	Slim-Hole Exploration Requires Proper Technical Preparation. *Proc. Soc. Pet. Eng. Annual Technology Conference and Exhibition, Houston.* Part 2 (of 5). p.235-244	
	Shepherd,A.	1986	Issues in the Training of Process Operators. *International Journal of Industrial Ergonomics*, v1, 49-64.	
	Staples,L.J.	1993	Task Analysis Process for a New Reactor. *Proc 37th Annual Meeting of the Human Factors and Ergonomics Society, Seattle.* {Human Factors and Ergonomics Society Inc., Santa Monica} p.1024-1028	
	Sutherland,V.J, and Cooper,C.L.	1984	Occupational Stress in the Offshore Oil and Gas Industry. In *International Reviews of Ergonomics: Current Trends in Human Factors Research and Practice.* Volume 3, ed. D.J.Oborne {Taylor & Francis}	
	Tompkins,B.G, Watson,W.D, *et alia*	1982	Human Factors Affect Panel/Console Design for Offshore Facility. *Oil and Gas Journal*, v80, n32, p.147-152	
	Wardell,R.W.	1989	The Application of Ergonomics to Oilwell Drilling Rigs. *Proceedings of the Human Factors Association of Canada 22nd Annual Conference, Mississauga, Ontario, 26-29 Nov.* p.135-139	
	Watson,W.D, and Moore,P.	1993	Momentum Kill Procedure Can Quickly Control Blowouts. *Oil and Gas Journal*, v91, n35, p.74-77	

Appendix B

U.S. Literature Search

SYSTEM SAFETY ANALYSIS TECHNIQUES

The purpose of a hazard analysis is to identify and evaluate hazards within a system in order to determine the safest, most efficient means of controlling the hazards identified. Generally, hazard analyses include the following (MSHA, 1986):

1. Gain an understanding of the system.

2. Define the scope and purpose of the analysis.

3. Select and apply an analysis technique.

4. Evaluate the results.

Hazard classification procedures are often used to establish priorities for correcting potential hazards or system failures. Hazards may be classified according to hazard severity and/or probability of hazard occurrence. The following hazard classification systems are typically used:

Category		Hazard Severity
I.	Catastrophic	May cause death or system loss.
II.	Critical	May cause severe injury, severe occupational illness, or major system damage.
III.	Marginal	May cause minor injury, minor occupational illness, or minor system damage.
IV.	Negligible	Will not result in injury, occupational illness, or system damage.

Level		Qualitative Hazard Probability
A.	Frequent	Likely to occur frequently.
B.	Reasonably Probable	Will occur several times in the life of the system
C.	Occasional	Likely to occur sometime in the life of the system.
D.	Remote	Unlikely to occur but possible.
E.	Extremely Improbable	Probability of occurrence cannot be distinguished from zero.
F.	Impossible	Physically impossible to occur.

Several hazard analysis techniques, also referred to as system safety analyses, have been developed. The most common of these analysis techniques are briefly described below.

GROSS HAZARD ANALYSIS (MSHA, 1986)

A gross hazard analysis (GHA) provides a general, qualitative assessment of a system's potential risks. The GHA, as its name implies, is a "gross" analysis of the system and is usually refined through additional evaluation. Brief descriptions of potential hazards are provided, with special consideration being given to the sources of energy and hazardous materials included in the system or its environment.

GHA normally uses a logic diagram or table in which potential high-risk situations are noted along with their possible causes. Additionally, for each hazard identified, preliminary means of control are provided.

FAILURE MODE AND EFFECTS ANALYSIS (MSHA, 1986)

A failure mode and effects analysis (FMEA) determines those components of the system where failures can occur and assesses the impact of the failures. The following information is listed on an FMEA chart: item, failure mode, effects on other items, effects on the system, probability of occurrence, severity level, criticality (probability X severity), detection methods, and remarks.

Items in the system are identified first, including people, equipment, materials, machine parts, and environmental elements necessary for system operation. The mode(s) in which each item can fail are then determined (e.g., a valve or switch can fail in a closed position or in an open position). Additionally, consideration must be given to the possibility of two or more items failing in combination since combined failures are often more severe than individual item failures. Next, the effects on other items within the system and those on overall system performance are considered. The seriousness of each failure or failure combination are then evaluated using Severity and Frequency Indexes (see descriptions in Operating Hazard Analysis section below). A Criticality Index, the product of the Severity and Frequency Indexes, is determined for each component of the system. Methods of detecting each failure are then determined, and any additional remarks are noted on the FMEA form.

The information gained from the FMEA is used to establish priorities for modifying the system to eliminate or minimize hazards or to reduce their consequences. The FMEA may also help to determine where additional failure detection methods are necessary.

TASK ANALYSIS (Salvendy, 1987; DeGreene, 1970)

Task analysis has been the most widely used human factors method of systems analysis. This technique describes and analyzes the performance demands made on the human elements of a system. This type of analysis provides data for human engineering design, determination of skill types and levels, and determination of training requirements. Task analyses should involve the following steps:

1. Specify the system criterion to the extent possible.
2. Determine the system functions.
3. Relate each function to a machine input or operator control.
4. For each function, determine the display information necessary for operator decisions to activate a control or monitor a system state.
5. Determine indications of control-activation adequacy fed back to the operator.
6. Determine environmental effects and constraints.
7. Determine time loadings on the operator and the frequency of task repetitions.
8. Determine special skill requirements.
9. Determine special criticalities.
10. Make certain that each stimulus is linked to a response and each response to a stimulus.

Task analyses may be presented in a variety of formats, including tables, graphs, and matrices. The wide variety of systems being evaluated precludes the standardization of formats.

OPERATIONAL SEQUENCE DIAGRAM (Salvendy, 1987)

An operational sequence diagram (OSD) graphically depicts the information-decision sequences a system must undergo to complete a mission. An OSD has the three main uses (Kurke, 1961, from Salvendy, 1987): to establish sequence-of-operations requirements between subsystem interfaces at various levels of system analysis; to depict the logical result of each of several decision-action sequences; and to evaluate panel layout and work-space designs. The central concept of an OSD is the decision. Information comes to the component (e.g., the operator), a decision is made, and an action is taken.

The following set of standard symbols is used to represent manual operations in an OSD:

Hexagon - operator decision

Square - action (e.g., control operation)

Triangle resting on point - transmitted information

Circle - received information (e.g., indicator display)

Half oval resting on round end - previously stored information (e.g., knowledge)

In addition to the above symbols, the following depict special codes:

Double-lined symbols - automatic operations

Solid symbols - no action or no information

Half-filled symbols - partial information or incorrect operations owing to noise or error sources in the system

OPERATING HAZARD ANALYSIS

An operating hazard analysis (OHA) considers foreseeable misuses of equipment from the perspective of the operator/user, concentrating more on behavioral aspects rather than the integrity of the components. OHAs may be presented in a table or a prose format. The OHA is performed by analyzing each operating mode of the system, including the components involved in that operating mode, a description of the potential hazards associated with proper use and misuse of the equipment, and the hazard effects. The OHA also implements a Severity Index and a Frequency Index. Severity may be divided into four classifications with associated Severity Indexes as follows:

Negligible (0.0 - 0.2):	Failure will not result in damage to equipment. Less than minor injury will result from the failure.
Marginal (0.3 - 0.5):	Failure will result in minor damage to equipment. Repairs are not necessary. Failure will result in minor injury.
Critical (0.6 - 0.8):	Failure will result in substantial damage to equipment. Immediate repair/replacement is necessary. Failure will result in severe injury.
Catastrophic (0.9 - 1.0):	Failure will result in severe damage to equipment. Immediate replacement is necessary. Failure will result in severe injury or death.

Hazard frequency, with the associated Frequency Indexes, may be classified as follows:

Extremely remote (0.0 - 0.2):	Assumed not to occur within the life of the system.
Remote (0.3 - 0.5):	Not likely, but possible, to occur within the life of the system.
Reasonably probable (0.6 - 0.8):	Likely to occur once within the life of the system.

Probable (0.9 - 1.0): Likely to occur several times within the life of the system.

The Risk Index, which is the product of the Severity and Frequency Indexes for each condition, is calculated to determine those hazards which warrant further investigation.

FAULT TREE ANALYSIS (MSHA, 1986)

A fault tree analysis (FTA) employs a logic diagram or "fault tree" to determine the causes of an undesired event. Only one event is analyzed in a single fault tree. This undesired event is located at the top of the fault tree, and all of the circumstances that can lead to the event are determined. These circumstances are then broken down into the events that can produce them, and this process continues until all events and their sources are identified.

Certain shapes and symbols are used in the FTA to represent events and their logical relationships. Characteristics of the event are indicated through the use of circles, rectangles, diamonds, and house-shaped figures. Additionally, "logic gates" (e.g., "and" gates, "or" gates) are used to show the manner in which events at one level of a fault tree combine to produce an event at the next higher level.

Evaluation of the sequence of events is made easier through the use of these symbols and shapes. Mathematical techniques are used to evaluate the events qualitatively, although many evaluations are often based on subjective opinions, experience, and judgment. The FTA provides a means to determine the overall likelihood of the undesired event, the event sequences and combinations that are most likely to occur, and the events that contribute the most to these sequences and combinations.

TECHNIQUE FOR HUMAN ERROR RATE PREDICTION (MSHA, 1986)

When specific behaviors are repeated many times it is possible to evaluate and predict human error involved in an operation. The Technique for Human Error Rate Prediction (THERP) is one method used for such evaluations. The basic steps involved in a THERP analysis are as follows:

1. Select an undesired event or system failure for study.

2. Identify all human tasks that may contribute to the occurrence of the undesired event.

3. Separate each task into "behaviors."

4. Assign a "basic error rate" to each "behavior."

5. Determine the category of the potential error associated with the "behavior."

6. Introduce countermeasures to control the error.

THERP uses "behavior" as the basic unit of evaluation. Each behavior can be divided into the following three elements:

1. Inputs - stimuli that are available or necessary for the behavior (e.g., instructions, signals, movement, labels, gauges, etc.)

2. Mediation - a mental process that leads to a decision (e.g., identification, recognition, reasoning, judgment, etc.)

3. Outputs - actions such as changing the positions of objects, levers, switches, etc., or giving oral or written responses.

Each event may be further described by the types of errors committed. For each of the elements of "behavior" described above, errors may be classified as intentional, unintentional, or by omission.

THERP also utilizes a "basic error rate," which assumes that the rate of human error for a particular behavior is relatively consistent among different tasks. Basic error rates are derived from experience or data from studies of tasks that include identical behaviors and are expressed as the number of errors per million behavior occurrences. Those errors that are most likely to lead to an accident are given first priority for control, and basic error rates are adjusted as these controls are incorporated. Controls are incorporated until human error is deemed as an unlikely contributing source to the undesired event. It should be noted that the use of THERP is somewhat limited due to the present lack of accurate error rate data.

DESCRIPTION OF OFFSHORE DRILLING OPERATIONS

WELL KICKS

(excerpts from Petroleum Extension Service, 1968)

General

A well kick occurs when the well pressure drops below the formation pressure. This may be caused by a drop in the drilling mud density and/or when the pipe is being pulled out of the hole, causing a pressure reduction. The first positive indication of an impending well kick is an increase in volume of the drilling mud in the pit. Increasing volume in the pit may be determined by many methods, ranging from simply having a rope with a metal object tied to its end hanging over the pit suspended at mud level, to using more elaborate mechanical pit-level indicators and mud-flow sensors. The author notes that it is good practice to work with small volumes of mud on the surface when drilling small holes so that small changes in volume can be detected before too much fluid enters the hole.

Well Kicks While Circulating

A kick which occurs while circulating will result in an increase in pit volume. Additionally, just prior to, and during the kick, there is normally an increase in drilling rate, a decrease in pump pressure, and an increased pump speed.

Well Kicks When Pump is Shut Down

When the pump is shut down during a well kick, there will be returns at the flow line, indicating formation fluid flow (i.e., formation pressure is greater than hydrostatic pressure alone) and the need to increase mud density. It should be noted that a discharge at the flow line when the pump is off is not always cause for concern. If a lost circulation has occurred (i.e., drilling mud was lost to fractures, permeable formation, etc.) and the mud weight was subsequently reduced, the formation may give up some of the lost mud when the pump is shut down. In this case, no increase in mud density is necessary.

Well Kicks When Coming Out of the Hole

Because the hole pressure may be reduced to a value less than formation pressure when pipe is being pulled out of the hole, kicks often occur at this time. This condition can be recognized when the hole does not take the an adequate volume of mud to compensate for pipe displacement, indicating formation fluid flow into the hole.

Blowout Prevention

When it is discovered that the well has kicked, the most direct way of determining the additional pressure required to stop the flow into the hole is to pick up the kelly (i.e., the uppermost pipe of the drill pipe string), stop the pump, close the well in, and read the pressure on the standpipe gage after pressure stabilization. The driller should then slowly start the pump and observe the buildup of pressure on the standpipe gage. (NOTE: The standpipe is the pipe through which mud is pumped, by way of the kelly hose, into the hole.) The pressure at which flow starts as the valve opens should be noted and the weight of mud required to balance the formation pressure, along with a safety factor for sufficient overbalance, should be calculated.

SURFACE VESSEL (SUPPLY SHIP) OPERATIONS

(excerpts from Gibson, 1992)

General

— supply ships are usually required to berth and unberth in extremely restricted areas

— snatching cargo at offshore installations has now become the rule rather than the exception; during transit the crane lowers its hook and the lift is attached and lifted off the vessel; remaining within the range of the crane boom is, therefore, probably the most important supply ship activity

— offshore cranes have also developed with this in mind, and the cranes on more modern platforms can reach any part of the vessel while it stands off at a reasonable distance; however, some rig cranes with extremely short jibs are still in service

Positioning the Ship

— the classic snatching position is on the lee side of the platform with the vessel at right angles to the rig; this position gives the best view from the bridge regardless of the position of the funnels and also provides the quickest means of escape from the locality of the installation

— the ship must then be held in position if it starts to drift off target

Heavy Lifts

— heavy lifts restrict the radius of the crane's safe operating area, thus the ship must be closer to the platform than would otherwise be required; on most rigs this requires that the ship be extremely close and that the lift be placed as far aft as possible

— must also consider the vertical movement of the ship; the big block is always extremely slow, so the crane driver cannot follow the movement of the ship; thus, it is possible for a lift to land heavily enough to damage the deck or some part of the deck structure

Joystick Operation

- single-stick maneuvering capability is now a requirement for virtually all vessels operating in the North Sea; to allow cargo operations to take place without the use of ropes and to allow the master to handle the ship for very long periods

- the joystick is connected to a computer which is interfaced with the gyro-compass to maintain the set heading; the computer activates the engines, thrusters, and rudders to move the ship in that direction

Tying up to Offshore Installations

- in the North Sea, tying up is becoming less and less common; even if weather conditions are calm and ropes are available, many masters prefer to snatch

- in extremely calm offshore waters (e.g., the Gulf of Mexico), the installations have facilities for supply ships to tie up alongside

- Procedure: ships drop anchor some way off the installation and then back up into the wind or current until they are within range of the crane; distance of anchor from the rig depends principally on the amount of cable carried by the ship

Anchor Handling

- an exploration rig is held in place by a spread of 8-10 anchors, and it must remain in that position for the duration of the hole

- anchor handlers must run the anchors out from the rig and position them on the sea bed at the correct distance

- anchors must be capable of being recovered and returned to the rig

Stowing and Securing Cargo in Port

- cargo on offshore supply vessels is stowed on the deck (relatively simple location); all cargo arrives in a unitized state and is all pre-slung so that it can be removed from the vessel with reasonable ease

- basic unit of cargo is the container, ranging in size from 40 X 48 inch internal dimensions to 20 foot high containers

- non-standard loads may include well testing and flaring equipment, generators, scaffolding, tubulars (e.g., casing, drill pipe, marine riser and piles), etc.

- other cargoes which must be given special consideration include helifuel tanks (explosive) and food

- a chain should be fixed across the aft end of the vessel for cargo to be loaded against

- cargo is usually loaded solidly from aft to forward and then secured at the fore end by running a tugger wire across it, attaching the hook to the crash barrier at one side and leading it through a snatch block at the other

- part cargoes are most frequently loaded against one crash barrier and then secured with the tugger wires or by chaining them tightly using cargo chain and chain tensioners

Offshore Discharge of Cargo

- upon arrival at the offshore location, establish radio contact with the deck of the installation

- must establish timetable for offloading, crane positions, and best storage points for cargo

- deck crew assembles on deck wearing safety gear (at least steel-toe boots and safety helmets)

- main danger to deck crew during cargo work is the possibility of being crushed by containers (e.g., when waves get aboard, the coefficient of friction between the containers and the wooden deck is reduced, and heavy objects can easily move)

NOTE: Refer to "Crane Operations" section for further description of discharge procedures.

Discharge of Bulk Materials

- cargoes such as gas oil, potable water, drill water, drilling fluid (oil-based mud), and dry bulk materials such as cement and barytes for drilling fluid are discharged by means of hoses

- there is no problem with hoses as long as the vessel is tied up to the installation

- due to the complexity of the pipework within the vessel, it is easy to make errors which can result in accidental discharge of liquids or solids overside or of discharge of the wrong commodity to offshore installations; possible procedures for minimizing such accidents include: color coding lines/end caps, checking contents of tanks prior to discharge, checking valves, etc.

Mud Tank Cleaning Operations

- accumulated solids which settle out from the drilling liquid during carriage must be removed from the tanks using tank cleaning machines

CRANE OPERATIONS

(excerpts from Gibson, 1992, unless otherwise referenced)

General

- the deck crew should be trained to use hand signals to indicate to the crane driver what is happening on deck: pointing to the container which is being discharged and, after the hook is attached, signalling that the container is ready to be lifted

- "One for one" technique - platforms are usually limited for deck space and will seldom be able to take all cargo without first landing empty containers aboard the vessel; as one full container is lifted onto the platform, one empty one replaces it on the vessel; to get to the full cargo containers on the vessel, the deck crew will have to climb onto the top of the cargo and stand on the container to hook it on and are, therefore, unprotected and may slip down onto the deck or even over the side of the vessel

- for heavy lifts, the crane is required to use its large block and to reduce the radius at which it can lift to prevent overturning

- Although no data were found relating directly to crane accidents on offshore drilling rigs, Shapiro (1980) cites a study of mobile-crane accidents by Butler (1978). Of 176 accidents studied, the following types of accidents were noted: overturnings (49%); structural damage - human error (14%); boom over cab (14%); rope failures (13%); wind (6%); structural damage - machine defect (5%); miscellaneous - man crushed between counterweight and obstruction (<1%). The percentage of injuries and/or fatalities attributable to each type of accident are as follows: overturnings (71%); structural damage - human error (10%); boom over cab (3%); rope failures (10%); wind (0%); structural damage - machine defect (5%); miscellaneous (3%).

Safety Hook

- crane comes down with a 'leg' on the main hook of the whipline; on the end of the leg is a safety hook, which is usually operated by pushing a short lever on the back of the hook up or down, allowing the jaw to open and be put around the ring on the container lifting gear; safety hooks ensure that: 1) the cargo does not fall off the hook during transport, and 2) the crane does not become attached to the vessel

Crane Becoming Attached to the Ship

- if the hook does become attached to the ship, the crane driver can: 1) remain in the cab and let out the whipline, hoping that the deck crew of the supply ship can detach the hook, or 2) leave the cab before the crane is pulled into the ocean

- the author notes that the problem of a crane becoming attached to the ship could likely be diverted if lighter cargo handling equipment (i.e., crane leg and crane hook) were used, commensurate with the weight of the lifts (most currently have a working load of 20 tonnes, when a working load of only 5 tonnes would be adequate in most situations); this would allow for easier handling by the crew on deck and, if the crane did become attached to the ship, the legs would be more likely to break rather than pulling the crane overboard; the crane leg and hook could be changed for excessively heavy loads; the author notes that this is conventional cargo handling practice in other industries

Discharging Tubulars

- tag lines are normally required for the discharge of tubulars so that the lifts can be guided into the correct positions on the rig deck

- two legs are slung onto the main hook, and tag lines should be attached to the shackle above each hook so that they do not have to be tied on to each lift

REFERENCES

1. DeGreene, K.B. (1970). *Systems psychology*. New York: McGraw-Hill.

2. Gibson, V. (1992). *Supply ship operations*. London: Butterworth-Heinemann Ltd.

3. Mine Safety and Health Administration (MSHA) (1986). *System safety engineering*. (Safety Manual No. 15). U.S. Department of Labor: MSHA.

4. Petroleum Extension Service (1968). *Lessons in rotary drilling, unit II - lesson 2, drilling mud*. The University of Texas at Austin: Petroleum Extension Service.

5. Salvendy, G. (1987). *Handbook of human factors*. New York: John Wiley and Sons.

6. Shapiro, H.I. (1980). *Cranes and derricks*. New York: McGraw-Hill.

7. Sidorov, N.A. (1985). *Drilling oil and gas wells*. Moscow: MIR Publishers.

Appendix C

Shift Work and Work Schedules

So for example, let's examine a shift of 12-hour duration. These "compressed work weeks" involving less than five shift days can be denoted as 4-4-4-4. Table 1 below shows the rotating hours for this compressed 4-4-4-4 continuous work week:

Table 1.

Rotating hours and continuous work weeks for compressed 4-4-4-4 schedule

M	T	W	R	F	S	K	M	T	W	R	F	S	K	M	T	W	R	F	S	K	M	T	W	R	F	S	K
D	D	D	D	O	O	O	O	N	N	N	N	O	O	O	O	D	D	D	D	O	O	O	O	N	N	N	N

Where:

M = Monday, T = Tuesday, W = Wednesday, T = Thursday, F = Friday, S = Saturday and K = Sunday

D = Day Shift

N = Night Shift

O = Day Off

This means the worker has four days of DAY shift (twelve hours worked between 1000 and 2200 hours), four days off, four days of NIGHT shift (twelve hours worked between 2200 and 1000) and another four days off. This basic sequence repeats itself every 16 days. Hence the notation of 4-4-4-4: four days of one shift, 4 days off, 4 days of a different shift and 4 days off.

This notation can also be used to show any changes in work/rest cycles in a daily schedule composed of 24-hours, such as a 4-4-4-12 schedule for one day. For this example, in one 24-hour period, the worker works 4 hours, rests 4 hours, works 4 hours and rests 12 hours. This notation seems common in military settings where they are examining short bursts of continuous operations, like military training exercises or even the Desert Storm conflict.

Human-Factors Variables in Shift Work Research

Several factors are under investigation in shift work research. One includes the effect of circadian rhythm on performance. Circadian rhythm is also known as our internal biological clock. We have our own natural way of time keeping, which works on a 25-hour cycle. The circadian system has been shown to effect physiological and behavioral variables like body temperature, hormone secretion, alertness and reaction time (Moore-Ede, Sulzman, and Fuller, 1982). Discussion of circadian rhythms' effects are prevalent in rotating shift research and the third-shift (or NIGHT) worker. By way of example, it has been shown that third-shift workers factors not under control could be responsible for the results. These would include worker motivation, morale, management's outlook on labor scheduling, and individual differences in training and experience levels.

The schedules tried in industry run the full gamut of combinations of days on/off and hours of work per day, starting and stopping time and leave granted. Each industry is different, with unique needs and oftentimes union demands which conflict with management's desires. It is very difficult to draw any conclusions about the "best" schedule for a particular industry. Most research has examines schedules already in place and tries to figure out what the problems exist. The implementation of recommendations from research is a slow, tedious process. The 12-hour shift came about by an overwhelming acceptance by the workers who viewed this schedule as a panacea with more days off. In spite of the mixed results, some guidelines have emerged consistently from the literature.

Some Factors in 12-hour Shift Work

Some industries, like ones where intense physical labor is required, may not be good candidates for a 12-hour compressed schedule. Older workers adjust less easily to this new schedule. Some health problems are reported, including fatigue. Safety under degraded performance is always of concern. Fatigue is a natural result of extended workdays and compressed work weeks.

Scheduling of shifts. Scheduling is a compromise between the wants and needs of industry to maximize its output, sometimes at the expense of the worker. Research has shown that 4/4 (days on, days off) scheduling, for extended periods of time (more than 30 days) is better than 4/2. Workers maintained a higher level of performance under the 4/4 versus the 4/2 scheduling. Also, the 4/4 schedule results in fewer sick days and personal days away from work. The 4/4 schedule was also superior to the 6/2 schedule.

Shift start time variability played a large role in railroad safety engineer work shift length and schedules. Fatigue was shown to be a function more of the start time variability than the actual number of hours spend on duty. Coming to work at a consistent time is important.

Continuous operations require weekend work scheduling. The preferred schedule by workers' standards is the every other weekend off. This schedule guarantees every other Friday, Saturday and Sunday free. No employee works more than 3 consecutive days or nights and each has consecutive days off (Friday, Saturday and Sunday) every two weeks. The workers prefer the regularity and frequency of the weekends free for leisure. Management gains by minimizing time away from work, since no more than three consecutive days between Monday and Friday are off for any one employee - thus, maximizing communication among crew workers.

Rotation of shifts. There has been some controversy about permanent versus rotating shifts. However, even permanent shifts do not allow workers to fully adapt to evening or night work hours. The reality of our daytime-oriented society, combined with circadian rhythm constraints, preclude this adaptation. Also, nighttime work hours have been described as a hazard to be avoided. Theoretically, rotation of shifts allows the nighttime work hours to be spread out across a greater proportion of the workforce, thereby minimizing exposure of the individual worker.

The speed of rotation of shifts from morning through night has been studied. Speed of rotation for 8-hour shifts in the U.S. is usually slow, with 5-7 consecutive days followed by 5-7 consecutive nights. Extended workdays with 12-hours worked usually require faster rotations of 2-4 consecutive days on shift. Arguments can be made in favor of either rotation speeds. However, slow rotation seems more acceptable to workers. The slow rotation allows for some adaptation of circadian rhythms to the nighttime schedule. Workers' personal life seems to benefit from the advance planning that a slow rotation gives.

Fatigue factors. Fatigue is a natural by-product of extended work days and the compressed work week. Fatigue is brought on by more hours on the job, combined with fewer hours of sleep accomplished by most nighttime shift workers.

Fatigue can lead to decreased performance on certain types of tasks. Fatigue has other results - sleepiness and decreased alertness. There has been some correlation between accidents, injuries and subjective feelings of fatigue. Many workers have reported fatigue during the 9th-12th hour on the job. Break scheduling seems to be an effective way to break the consequences of fatigue.

Effect of environment on shift schedules and performance. Research has shown some positive effects of the specifics of the environment and 12-hour shifts. Studies where controlled environmental conditions existed for workers on 12-hour shifts found equal performance with workers on a less-demanding schedule. The less-demanding schedule was defined as the 8-hour work shift, where all physical demands are met by workers themselves on their off-duty periods. The controlled environmental conditions are those where all physical needs are provided - housing, food, recreation, etc.

One example where this environment was advantageous to performance is on an offshore oil refinery. Living and sleeping quarters are provided, along with meals and recreational facilities. Tightly enforced regulations and procedures to ensure safety are also a part of the offshore environment. Health of workers is more closely monitored in the offshore environment. Offshore workers live and work in a 24-hour environment where meals and recreational activities provide a similar routine for both day and night workers, so adaptation to night work is less difficult. There are no competing social and family demands on the offshore workers. Offshore employees also may have an environment with no windows and therefore, no natural light to interrupt sleep. However, this same offshore environment also had negative effects on workers. These effects are isolation, limited and confining living and working space, exposure to elements, potential hazards and very severe consequences of failures and oversights, lack of privacy and proximity to work mates during off-duty hours. Constant reminders of hazards and need for constant vigilance can lead to more anxiety among workers. The noise of the machinery, etc., can also be a distraction to sleep.

Task performance. Not all tasks suffer from the effects of fatigue equally. It has been shown that work involving heavy physical labor can result in fatigue. Repetitive or vigilance tasks have been shown to result in fatigue-induced performance after shorter periods of time (8 or fewer consecutive hours). Examples of industries where vigilance tasks might be prevalent are nuclear power plants, chemical, petroleum and oil refineries. Tasks involving eye-motor coordination have shown a decrease in performance over the 12-hour shift.

Break scheduling has been reported to be an important factor in alleviating the effects of fatigue on task performance. Breaks have been recommended to be customized for 12-hour shifts since workers report fatigue during the last few hours of the extended work day. Petroleum and chemical industries were cited as having rest periods available frequently. Therefore, although the job may be physically challenging, rest breaks ameliorated the fatigue effects.

Laboratory studies report good ability on the part of the worker to cope with longer shifts and compressed workweek (12 hour day). Other studies have said that performance deteriorates across 9-12 hours on shift. There are also individual differences to how individual workers respond to tasks, as a function of fatigue and extended workdays.

Accidents and the 12-hour shift (compressed work week). There are conflicting results from studies on this subject. Extended hours intensify errors during night shifts, particularly between the hours of 0300 and 0600. Another look at accidents expands the window when most accidents occur to between 0200 and 0600 hours. Accident and injury analyses show more accidents occur in the last three hours of the shift. Accident frequency for certain injuries increased (specifically ladder falls) and overtime accidents increased. Accidents in some of these studies refer to worker injuries.

In a study of the 12-hour shift in petroleum and chemical industries, none of over 50 plants surveyed reported increased accidents as a results of the 12-hour schedule. However, these plants put an increased emphasis on and monitoring of safety procedures while the 12-hour shift was being implemented.

When accidents are on the rise, they are attributed to working long hours and fatigue, as well as increased risk due to exposure. It makes sense that if you are at work for longer numbers of hours, then your probability of being injured due to exposure to danger for more hours could increase.

In an exhaustive review of extended workdays and safety, there is little objective information on the nature and degree of safety and health risk associated with extended workdays. Although, some industrial groups, like mining, chemical and oil refineries have displayed increased or more serious accidents.

Some positives on the 12-hour shift. The increase in workers' days off is an obvious off-shoot of the 12-hour shift. Workers generally have an overwhelmingly positive attitude and support of the 12-hour shift, presumably due to the increased days off. Worker morale was found to improve in the petroleum and chemical industries studies, which might offset some of the negative effects of fatigue.

Physiological measures examined did not suffer under the 12-hour schedule.

The every other weekend off schedule, as opposed to the 3/3 or 4/4 or traditional 6/2, might be the schedule which would win the favor of most employees. Maximum flexibility in scheduling personal time and leisure is seen as the plus.

In the offshore environment, there are no competing social and family demands. When they are at work, workers are concentrating on their tasks. When they are off work and on shore with their families, they can concentrate on that part of their lives.

Summary

We are becoming more familiar with the capabilities and limitations of the human being in different settings. We recognize circadian rhythm and its effect on behavior and performance. We know about fatigue and its relationship to certain types of task performance. However, every set of circumstances encountered in an industry is different. It is different for a number of reasons including demographics, workforce composition, nature of tasks on the job, long-term effects of schedule changes, experience level of the workforce, health of workforce and other factors outside one's control.

The industry considering or employing a compressed work week and extended work days must look closely at many factors. The age of the employees - where older workers do not adjust well to longer work days. The experience and motivation of employees, combined with their physical health, can reduce the negative effects of fatigue, decreased alertness and sleepiness. This reduction in fatigue can also lead to fewer accidents. Rest break periods should be scheduled judiciously, especially toward the end of the 12-hour shifts - the last 3 hours or so.

The specifics of the types of tasks being performed by the employees must be evaluated to see how they respond to fatigue. A closed or restricted environment should be considered for specific industries with extended work week schedules, like offshore oil refineries. The positive offshoots of the confined environment may outweigh the negative factors. Workers do not have to deal with competing social and family demands. Their physical demands are met - housing meals and social and recreational activities.

Shift scheduling appears to favor the 4/4. The every other weekend off is the favorite of workers, if management can make it work to meet their goals of productivity.

The realization of the 12-hour day, compressed work week is upon us. There are large individual differences in response to this schedule and every industry has differing experiences (positive and negative) and problems with the compressed work week. The particulars of the industry, tasks, work force age, health, motivation, etc. and management's attitude play a large role in the success of the 12-hour day, compressed work week.

Annotated Bibliography

Work Shifts, Compressed Work Week, Safety

Trumball, R. (1966). Diurnal cycles and work-rest scheduling in unusual environments. *Human Factors, 8*(5), 385-398.

Almost 90 articles are reviewed, spanning the turn of the century to mid 1960s having to do with man's neuro-physiological and psychological rhythms. Reviews diurnal cycle, which at the time of this article's publication, was a new notion of circadian cycles. Examines military research into work/rest cycles during the 1960s. Refers to a Lockheed study for military where 15 days of 4 on/2 off and 30 days of 4 on/4 off were studied. Conclusion drawn was 4 on/4 off demonstrated superiority in maintaining performance. Factors found to influence results, regardless of schedule, are: motivation, pacing, change of work, sleeping arrangements (on-site), previous training and level of skill.

Looks at factor of sleep and sleep loss on performance. Reviews studies done in 30s through 60s. Discusses consequences of sleep loss of up to 120 hours.

Morgan, B.B., Jr., Brown, B.R., Alluisi, E.A. (1974). Effects on sustained performance of 48 hours of continuous work and sleep loss. *Human Factors*, *16*(4), 406-414.

Work efficiency of 10 subjects during a 48-hour period of continuous work and sleep loss was assessed using the synthetic-work technique. Performance during the period of stress was found to be significantly influenced by circadian rhythm. Decrements first occurred after approximately 18 hours of continuous work and performance decreased to an average of 82% of baseline during the early morning hours of the first night. Performance improved to about 90% of baseline during the daytime of the second day but decreased to approximately 67% during that night. All measures of performance recovered to baseline levels following a 24-hour period of rest and recovery.

The notation used in this article appears to be the military's way of denoting how a 24-hour daily schedule is managed. Therefore, the numbers described refer to hours on/off.

Previous studies of 48-hour schedules found mixed results, with motor coordination and target-identification tasks suffering, as well as driving tests. Other functions did not suffer any decrement. Previous study (Alluisi, 1969) found subjects working 4-4 work-rest under controlled environmental conditions, working 12 hours a day with all physical needs provided, can perform as well as those on the less-demanding 4-4-4-12 schedule (or working 8 hours per day, where subjects have to meet their own demands during off-duty periods).

In this study, a specially-built device was used to test levels of performance in several different areas. Schedule of work was 4-4-4-12 for two days, continuous for 48 hours, 24 hour rest and then 4-4-4-12 schedule resumed. Individual and group work performances decreased significantly during the 48-hour period of continuous work and sleep loss, with largest decrements occurring between 0200-0600 hours.

Janaro, R.E., Bechtold, S.E. (1985). A study of the reduction of fatigue impact on productivity through optimal rest break scheduling. *Human Factors*, *27*(4), 459-466.

Using a new model (variable-k with penalty), authors attempt to determine optimal individual rest break policy. Goal is to maximize worker output over a specified time period. Rest break policy consists of the number, duration and placement of rest breaks. Rest break has an associated time penalty - time it takes to take a break and resume work again. Rest breaks in this model are unevenly spaced. Model tested in a non-industrial setting, with highly motivated and rewarded subjects. When model applied to rest breaks placed to enhance fatigue recovery, subjects exhibited a 13% increase in productivity. This article is probably not applicable to particular problem at hand - the research presented here is too theoretical, and involves the development of a new model, etc.

Pokorny, M.L.I., Blom, D.H.J., van Leeuwen, P., van Nooten, W.N. (1987). Shift sequences, duration of rest periods, and accident risk of bus drivers. *Human Factors*, *29*(1), 73-82.

Bus accidents and type of shift were analyzed. Past research indicated there was an increased tendency towards a higher risk of accident the earlier one started working. In addition to type of shift worked when accident occurred, question arose if the sequence of shifts and days off influenced actual accident risk on a given day. Results showed no interaction between type of shift on preceding day, actual shift and bus drivers' accident risk. Two successive days off did not have an effect. No association was found between total duration of rest periods and accident risk. Conclusion drawn was that accident risk may be determined by actual situation on the working day (type of shift, starting time and duration of work) rather than by interruptions in course of working day or by events on preceding days.

Baker, K., Olson, J., and Morisseau, D. (1994). Work practices, fatigue, and nuclear power plant safety performance. *Human Factors*, *36*(2), 224-257.

Paper examines work practices contributing to fatigue-induced performance decrements in nuclear power plants. Examined amount of overtime worked by different types of personnel (operations, technical and maintenance) and 12-hour shift schedule. Although there was a lot of overtime for all three job categories, only overtime worked by operations personnel affected plant safety performance. Conclusion drawn was operations overtime represents safety concern in nuclear power plant industry, but more research necessary.

Extended work hours intensify errors during night shifts, particularly between 0300 and 0600 hours. Repetitive or vigilance tasks result in fatigue-induced performance after shorter periods (8 or fewer consecutive hours). Study of petroleum and chemical industries found adopting a 12-

hour shift improved worker morale, which might offset negative effects of fatigue (Northrup, Wilson and Rose, 1979).

Duchon, J.C., Keran, C.M. and Smith, T.J. (1994). Extended workdays in an underground mine: a work performance analysis. *Human Factors*, *36*(2), 258-268.

Shiftworkers in some sectors (chemical and oil refining given as examples) display decreased performance, increased or more serious accidents, lower production, higher absenteeism, health and family problems, etc., when they work nights and rotating shifts. Studied a new 12-hour extended workday and compressed workweek schedule for underground miners. Conclusions were workers overwhelmingly supported the 12-hour schedule and physiological measures did not show indications of physical fatigue. One behavioral task (tapping) out of a battery of four showed decrease in performance with 12-hour shift. Breaks should be customized for 12-hour shifts since workers report fatigue during last few hours of extended work day. Decided to keep extended workday schedule in mining, but needs to be continually reevaluated.

Paley, M.J. and Tepas, D.I. (1994). Fatigue and the shiftworker: firefighters working on a rotating shift schedule. *Human Factors*, *36*(2), 269-284.

Fatigue, viewed as a simple variable positively correlated with time on task and produced by physical activity, was the variable under study for firefighters. Regulations for hours of service treat all hours of day as equal and interchangeable. Guidelines attempt to minimize accidents by governing number of hours operators work and rest. - not an adequate safety control. This study looks at time-of-day (shift) differences for sleep, sleepiness and mood (MAYBE TOO "SOFT" DATA FOR APPLICATION). Results do not generalize beyond firefighters on a biweekly rotation schedule where they rotated from night shift to afternoon/evening to day shift.. Found fatigue is affected by time of day

Effects of shiftwork found to be poorer health, work stress, reduction in sleep length. Reduced-sleep studies abound and report findings of problems like fatigue, sleepiness, irritability, inability to concentrate and bad moods.

Mead, K.M. (1992). Railroad safety engineer work shift length and schedule variability: Statement of Kenneth M. Mead, Director, Transportation Issues, Resources, Community, and Economic Development Division, before the Subcommittee on Transportation and Hazardous Materials, Committee on Energy and Commerce, House of Representatives. GAO/T-RCEO-92-68.

Testimony on shift length and accidents for railroad engineers. Four railroads surveyed and found that reducing maximum number of hours allowed per shift from 12 to 10 could have little effect on accidents (4.5% of all human-factor-caused accidents occurred after 10 hours in an engineer's shift). Biggest problem found was start time variability, which would increase with a decrease in hours of service to 10 - allowing more variability of time to start shift. Fatigue is a function more of start time variability than number of hours on duty. Most accidents occurred during 0200-0600 time period and during the second through the sixth hour on duty.

Duchon, J.C. and Smith, T. (1993). Extended workdays in mining and other industries: A review of the literature. U.S. Department of the Interior: Bureau of Mines Information Circular: Washington, D.C.

Reviewed literature of field, laboratory and accident analysis studies. Table 1 is a nice summary of results of long-work hours on different dependent variables studied for all types of studies. Military study of sustained operations conclude that humans can work 15-36 hours continuously with little or no sleep before performance manifests significant decrements. However, these are short spurts - 2-5 days of activity. Laboratory studies have mixed results - the military sustained operations' results say a worker's ability to cope with longer shifts and compressed workweek (12 hour day) is good, while other say performance deteriorates across 9-12 hours. Field studies depend on the industry, job, conditions, environment, the performance measure, as well as management's attitude. Therefore, results are also mixed. Accident and injury analyses are no more clear. Workers like the compressed workweek since it gives them more days off. However, in some industries, some studies found performance and/or safety decrements associated with extended workdays.

Schroeder, D.J. and Goulden, D.R. (1983). ***A bibliography on shift work research: 1950-1982*** **(FAA-AM-83-17). Washington, D.C.: Federal Aviation Administration, Office of Aviation Medicine.**

Excellent bibliography compiled of over 1300 documents published over a 30-year period. Bibliography developed as part of a research task concerned with impact of shift work on employee job satisfaction, productivity, perceived job difficulty, and subjective health. Excludes references to assessment of circadian effects on physiological responses and performance. Good source for references up through 1982.

Northrup, H.R., Wilson, J.T. and Rose, K.M. (1979). The twelve-hour shift in the petroleum and chemical industries. ***Industrial and Labor Relations Review, 32*****(3), 312-326.**

Based on survey of fifty plants using 12-hour shift in chemical and petroleum industries. Article summarizes the three schedules prevalent: EOWEO (every other weekend off); three-on, three-off rotating and four-on, four-off rotating schedule. See Figures 3, and 4, page 315 and Figure 5, page 316, for details of three schedules.

EOWEO was most popular and means worker works 42-hour weeks on average and guaranteed every other Friday, Saturday and Sunday off. No employee works more than 3 consecutive days or nights and each has 3 consecutive days off (Fri, Sat and Sun) every two weeks, and also 4 weekdays off. In addition to benefits to workers due to regularity and frequency of weekends free for leisure, management see it as minimizing time away from work (no more than 2 days consecutive between Mon., and Fri.), hence increasing communication between workers.

Second most popular was 3-on, 3-off schedule also averages 42 hrs/week. Twelve-week cycle means worker has two 3-day weekends and two 2-day weekends every 12 weeks. Every 2-day weekend is followed by 3-day weekend, which is then followed by 4 consecutive weekends during which one or both days are worked.

4-on, 4-off has 16-week cycle and also averages 42 hrs/week Four 3-day weekends and two 2-day weekends are offered. Other 10 weekends allow at least one day off.

Several wage and manning factors (such as overtime pay, holiday pay, Fair Labor Standards Act, shift differentials, overtime manning, unscheduled overtime) are discussed and how the plants dealt with each when changing from an 8-hour to 12-hour/day shift.

Non-wage factors are also discussed. Absenteeism and turnover are reduced and employee satisfaction and morale increased and physical health did not get worse and some reported an improvement. Fatigue and accident rate were closely monitored for the first trial periods. None of the 50 locations surveyed reported increased accidents as result of new 12-hour schedule. Because of fears management had over accidents due to fatigue, an increased emphasis was put on precautionary measures during the new 12-hour schedule and also employees recognized they might be more likely to make mistakes because of fatigue. Article could/would not speculate on whether this heightened conscientiousness and good safety performance would continue.

Older workers had problems adjusting to new schedule. Industries requiring more fatiguing physical labor may not do well with 12-hour shift. Petroleum and chemical industries were cited as having rest periods available frequently. Therefore, although the job could be physically challenging, rest breaks ameliorated the fatigue effects.

Eli Lilly introduced 12-hour shift in 1955 and Imperial Oil (Exxon controlled) used it in 1970. Article predicted continued use in oil industry if cost was equivalent to 8-hour shift, safety standards and support of employees maintained, no increase in accident frequency and no OSHA violations.

Parkes, K.R. (1992). Mental health in the oil industry: a comparative study of onshore and offshore employees. *Psychological Medicine, 22*, 997-1009.

Studies the mental health of North Sea offshore employees relative to onshore counterparts. Used General Health Questionnaire scores to show anxiety was significantly higher among offshore workers than onshore, but found no significant differences in somatic symptoms or social dysfunction. Result was not affect by age, job level and neuroticism. The nature of offshore environment, and factors which play a causal role in elevated anxiety among offshore workers are discussed.

Sunde [reference is Sunde, A. (1983). Psychosocial aspects of offshore work. In *Safety and Health in the Oil and Gas Extractive Industries*, pp. 176-187. Graham & Trotman, Ltd., for the Commission of European Communities: London, England] lists adverse offshore work effects:

confined living and working areas, procedural constraints, continuous emphasis on safety, nature of work cycle and shift schedules, lack of privacy and proximity to work mates during off-duty hours, adverse physical environment (noise and temperature) and risk of helicopter travel. Positive factors are favorable pay rates and long periods of leave, careful monitoring of health, restrictions on smoking and alcohol and availability of offshore health services and lower retirement age.

This study examined 84 control-room personnel working on three oil platforms in UK sector of North Sea and 88 onshore control-room operators at six terminals in Scotland and N. of England. All were male. Findings are interpretations of tests administered to examine general health and anxiety, somatic symptoms and social dysfunction. Results were onshore group reported significantly lower symptom levels while offshore sample did not differ significantly from published mean of General Health Questionnaire normative data. Results are interpreted that offshore employees are to some extent self-selected. Psychological factors play a part in the decision to seek offshore employment. Also offshore employees must pass a medical examination to ensure their physical and mental well-being for the demands of the North Sea environment, with medical checks regularly (based on age) for continued employment.

Offshore workers had higher anxiety levels than their onshore counterparts. This is explained by the offshore environment playing a causal role. Nature of North Sea employment exposes offshore personnel to variety of psychosocial and physical environment stressors which may be causally linked to levels of anxiety and tension. The constraints of tightly enforced regulations and procedures to ensure safety are present in the offshore environment due to factors of isolation, limited space, exposure to elements, potential hazards and consequences of failures and oversights with more serious consequences. There are constant reminders of hazards and need for constant vigilance. Other factors could be shift schedules and work/leave patterns. The same shift patterns of two-week offshore cycle with 7 night shifts followed immediately by 7 day shifts (each 12-hours each) had to be used.

Another reference found was:

Cooper, C.L., and Sutherland, V.J. (1987). Job stress, mental health, and accidents among offshore workers in the oil and gas extraction industries. *Journal of Occupational Medicine, 29*, 119-125.

Duchon, J.C. and Smith, T.J.(1993) Extended workdays and safety. *International Journal of Industrial Ergonomics,* 11, 37-49.

This article by Duchon and Smith is somewhat a repeat of some of the same background and research reported by this author in previous articles (see above). In review of the literature, they state that some studies have shown that industrial groups like mining, chemical and oil refineries have "displayed perturbed performance, increased or more serious accidents" among other problems related to working nights and shift-work. They report there is very little objective information on the nature and degree of safety and health risk associated with extended workdays.

For 8-h shifts, they report the U.S. speed of rotation of shifts is usually slow (5-7 consecutive nights followed by 5-7 consecutive days. Extended workdays usually require faster rotations of 2-4 consecutive days. The same Table 1 is presented as used in the Bureau of Mines Information Circular reviewed above which summarized the laboratory, field and accident/injury analyses and the results. Laboratory studies for the most part have either neutral or negative results of extended workday on their dependent variable. Only four variables out of 35+ reviewed showed any positive effect and they were for performance tasks, management report of performance, ergometry and blood pressure.

Both surveys done in field studies had positive results. The studies looked at oil refinery and chemical and petroleum industries.

Accident and injury analyses showed more accidents in the last 3-h of the shift, accident frequency for ladder falls increased, overtime accidents increased as did musculoskeletal disorders and backpain. Only one study (Lees and Laundry, 1989), showed a positive result whereby accidents frequency and health complaints in extended workdays in manufacturing and 12-h shifts decreased.

In studies where accidents increased, they were attributed to working long hours and fatigue, as well as increased risk due to exposure (you are at the plant longer and exposed to danger for more hours).

Caution again is required when drawing conclusions and extrapolating results of research. The authors looked at different dependent measures, do not control for type of work task performed, workforce characteristics and management's outlook. These authors are willing to say that workers like the extended workdays because of the days off it gives them. Some studies for some industries have shown performance/safety decrements with extended workdays. More research is required, especially in industries where safety is of major importance.

Parkes, K.R. (1994). Sleep patterns, shiftwork, and individual differences: a comparison of onshore and offshore control-room operators. *Ergonomics, 37*(5), 827-844.

An obvious offshoot of her research reported in *Psychological Medicine* above, Parkes reports on sleep patterns of offshore and onshore workers. On the topic of shift-rotation in her review of the literature, she says the most widely studied shift system associated with the 8-h shift involves either weekly or every two weeks rotation from early to afternoon to night shift. Recently, weekly rotation has given way to fast rotation where no more than 2-3 night shifts are worked consecutively. In 12-h shifts, there is a greater subjective fatigue and performance decrements than 8-h shifts.

Because of the offshore environment, with living and sleeping accommodations limiting personnel on board at any one time, a fast-rotation is not practical since expense to move people to and from shore is prohibitive (helicopter rides, etc.). Normal offshore work period is 2 weeks. Alekperov et al. (1988) compared 7-day work periods on oil rigs with 15-days and found, based on physiological data, that the 7-day schedule was better. However, the 2-week duty cycle where 12-h work periods alternate with 12-h rest periods is the normal for offshore employees in North Sea. Seven night shifts are followed by 7-day shifts, enabling worked to return to shore in the "day" mode.

Past research shows individual differences in response to shiftwork, older workers have more trouble adjusting, prolonged shiftwork may have harmful effects, workers experience anxiety, sleep problems and other neuroticism.

Parkes study looked at control-room operators - with the same job at both offshore and onshore facilities. The offshore personnel changed from night shift to day shift after 1 week of the 2-week rotation (and then got 2-3 weeks of leave), while the onshore personnel worked fast-rotating schedules with no more than 2-3 consecutive night shifts.

Results showed that offshore workers were significantly younger than onshore workers (40.9 vs. 44.6 years). Sleep duration for offshore workers was best during leave, and worst during day shifts. The on-shore had more sleep during the day shifts than the night shifts, the opposite finding for offshore workers. Sleep quality showed the same pattern for all groups, with the onshore and offshore reporting opposite day versus night for worst sleep quality.

For the findings, the potential for impaired alertness is a problem and sleepiness during night shiftwork may endanger lives and safety implications. Offshore personnel live and work in a 24-h environment where meals and recreational activities provide a similar routine for both day and night workers. So adaptation to night work is less difficult. There are no competing social and family demands on the offshore workers. Offshore employees also have an environment with no windows and therefore, no natural light to interrupt sleep. Some offshore workers experienced difficulty in sleeping soundly at night because they were alerted by unusual changes in background noise and vibration, perhaps signaling an emergency.

Includes extensive bibliography, many are foreign authors, but reported in journals that we could get copies of, if needed. .

Krueger, G.P. (1989). Sustained work, fatigue, sleep loss and performance: a review of the issues. *Work and Stress, 3*, 129-141.

Main focus is on military sustained operations and their findings. Issues under study in the review are characteristics of job, work tasks, vigilance and attention, machine-paced vs. worker-paced tasks, physical versus cognitive tasks, rhythmic variations in worker performance, weariness, tiredness and fatigue and work/rest breaks.

Previous studies (Alluisi and Morgan, 1982) of men working blast furnaces 12-h/day, 7 days/week for an 84-h workweek, had a decrease in accidents, absenteeism and increased productivity when their workweek was shortened. **But the effects of total work hours on human performance and productivity interact with many factors and there is no single work schedule that works best for all tasks and all industries.**

Notation here follows the military work/rest schedule per 24-hour day. Shift rotation review shows no difference in scheduled of 4-h on duty and 2-h off versus 6-h on and 2-h off. Subjects preferred the 4-2 over the 6-2 and got more sleep. In 15 and 30-day studies of 4-2 and 4-4 schedules, those working 4-4 had a better level of performance maintained than the 4-2 group. When people worked 12 hour days on a 4-4 schedule, they maintain higher levels of performance than 16 -h days of 4-2 schedule. With highly motivated workers, performance over a period of 30 days on a 4-4 schedule is indistinguishable from those on a 8-h split-shift. Sixteen-h/day on a 4-2 schedule appears to be maximum hours per day a man should work for extended periods (note - 4 hours on and 2 hours off on this recommended schedule!).

Many other factors are at play in analyzing and interpreting results: prior rest, physical fitness, endurance, environmental conditions, time and day and task type. There are no easy answers!

Includes extensive reference section. Mainly sustained operations.

***Night and Shiftwork* (1993). *Ergonomics, 36*(1-3), 14-139. Edited Proceedings of the 10th International Symposium on Night and Shiftwork, Shiftwork Committee of the International Commission on Occupational Health, Sheffield, England.**

Just obtained the table of contents from this reference. There are many articles under the heading of Night and Shiftwork, a special issue. Some nay be of use, like "The design of shift systems, " by P. Knauth. Also "An experimental change of the speed of rotation of the morning and evening shift." by J.E.E. Ng-A-Tham and Hk. Thierry. There is a wide variability in the focus of the articles in this issue.

Yoder, T.A., and Botzum, G.D. (1972). The long-day, short-week in shift work: A human factors study. Eli Lilly and Company.

Reviews Eli Lilly's experience with a long-day, short week concept in place since 1969. Their schedule requires four crews with shift changes at 0600 and 1800 each day. The schedule followed is a 4/4 and then a 3/3. Crews rotate from day to night shift on a quarterly basis. They examined the sociological, psychological and physiological consequences of this compressed work week compared to the traditional shift (8 hours worked). To no surprise, the night shift workers got less sleep on their days off (compared to day workers). They also got more sleep on their days on duty, as well as just prior to and just after the shift duty. Data was compared for the 4/4 versus 3/3 and no differences were found in the amount of sleep decrement accumulating in the two shifts.

Four workers were studied for physiological changes. Physical capacity increased over the first three days and then declined on the fourth day to the level of day 1. The trend was opposite that expected if long hours produced deterioration in physical capacity for work. The decrease on the fourth day was postulated to be due to sleep loss and workers expending calories beyond one's physical capacity.

Thurston, S.C. (1981). ***The relationship between rotating shift work and accident rates in a steel tubular products mill.*** **Unpublished Masters Thesis, University of Cincinnati, Cincinnati, OH.**

Thesis dealt with examination of injuries to employees working a rotating shift. Shifts studies were three, 8-h shifts (overlapping by one hour; starting at 0700, 1500 and 2300). In reviewing the literature, the author points out the differences in conclusions drawn regarding many factors, including accidents. Some studies have found an increase in accidents at night, while others do not. Many studies found a higher severity rate for night shift. However, no conclusions can be drawn definitively, since different shift systems and industries are studied.

Study involved looking at copies of injury reports and breaking them down by different variables. No real surprises in the results. More injuries occurred to employees with 0-5 years of experience, with younger workers (correlated with experience). Other findings not summarized here, due to irrelevance to topic area.

Research not really germane to this topic.

Tippin, M.(1992). ***An examination of the compressed work week in a continuous operation.*** **Unpublished Masters Thesis, Loyola University of Chicago, Chicago, IL.**

Reviews reasons for and problems with shiftwork. Reports that C.F. Ehret noted that nuclear accidents at Chernobyl, Three Mile Island, and chemical disaster at Bophal may have resulted in human error during a night shift. Accidents at last two occurred on a night shift immediately following a shift rotation, where workers were on their first day on the new shift.

Reports the 12-hour shift schedule (known as "Dupont" schedule) incorporates three shift patterns, but with many variations possible. The first is the 3/3 or 3 days on/3 days off. Little in the way of research literature is available on this pattern.

The second is the 3/2/2 pattern or the following over a 2-week cycle - 2 days on/2days off/2 days on/3 days off/2 days on/2 days off. However, NOTE that this only accounts for 13 out of 14 days, so there is probably an error in the thesis text! I think it should be 3 days on/2 days off/2 days on/3 days off. Advantages are touted for business, but scheduling personal time for employees is difficult.

Third is the 4/4, 12-hour shift. Compared to the traditional 6/2 schedule, where one works six 8-hour shift, with two days off, the 4/4 is expected to have fewer "sick days" and greater harmony among the work crews. Disadvantages to the 4/4 is fatigue, possible safety problems and communications declining with employees away from their job for 4 days.

This research used surveys completed by employees and supervisors to compare the 4/4 with the 6/2 schedule. The author expected to find less personal business days, lower absentee rate, higher productivity and morale, better crew harmony and others.

Research is based on survey inventories which may be inappropriate for some of the hypotheses under test. All the problems with questionnaires surface and may impact the results. Data is rather "soft" with the exception of examination of personnel records on absenteeism and personal business days - which do decrease on the 4/4 shift over the 6/2 shift.

Appendix D

Role Evaluation Tool

ISSUE RECORD

Issue	Date	Description
1	14/5/97	Issued as Final Report

INTRODUCTION

The RET can be used on a range of work roles. Where safety critical roles and tasks have been identified, the RET can be used to assess the potential for human failure in such roles.

Definitions

The RET contains a number of terms which require definition. These definitions are as follows:

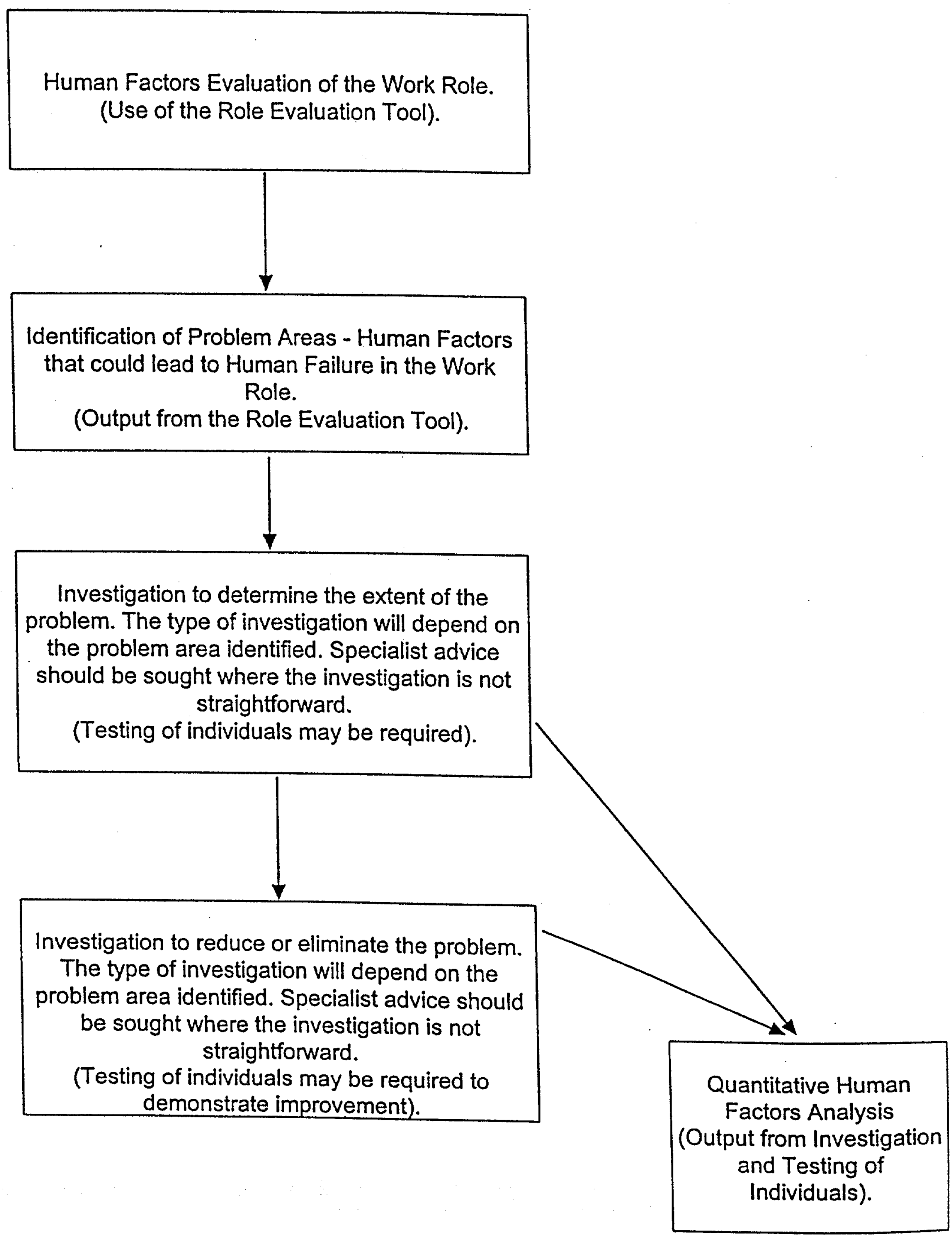
Psychological factors:	associated with human mental processes, for example, perception, memory, and attention.
Physiological factors:	associated with the (non mental) processes of the human body, for example thermoregulation, and heart rate.
Physical factors:	associated with the human body or physical matter, for example muscle build, and physical environment.
Role:	the work role an individual performs, for example Chef, Technician, Control Room Operator, Offshore Installation Manager. The role includes all tasks the role holder performs. This is also the case where a role involves multi-tasks, such as Operations and Maintenance Technician.
Human Failure:	all possible failures of the human mind and body. For example mental error, disease, and muscle or skeletal (musculo-skeletal) injury.
Safety Critical tasks:	tasks which if not performed successfully could result in serious injury, fatality, loss of containment, or major damage to an installation or the environment.

Uses of the RET

The RET has a number of uses. In particular, the RET:

- provides a consolidated, holistic approach to assessing human factors, and identifies many of the human factors which can impair performance and increase the potential for human failure,
- provides information on the effects of the role and the working environment on an individual's health and performance,
- optimises a role and the working environment to align with human capabilities,
- provides information for specifying competence assessment programmes,
- assists in the identification of training needs,
- assists in the setting of standards for measuring and managing work performance,
- and, assists in the investigation of incidents.

OVERALL APPROACH TO HUMAN FACTORS ASSESSMENTS USING THE RET



ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

A1. ROLE CHARACTERISTICS

The Role Characteristics are defined as the properties of the Role as opposed to the requirements of the Role. These properties can be as a result of the physical and personnel environment (culture and sub-culture) in which the Role is performed, hazards that exist as a result of the environment or as a result of the tasks performed within the Role, the Organisation which supports the Role, and the fact that the role is performed by humans who have variable qualities.

A1.1	Define the physical environment in which the role will be performed in terms of ambient temperature. What is the variation in this temperature. What are the extremes in terms of maximum and minimum temperature?
A1.2	Define the physical environment in which the role will be performed in terms of ambient radiative heat temperature. What is the variation in this temperature? What are the extremes in terms of the maximum and minimum radiative heat temperature?
A1.3	Define the physical environment in which the role will be performed in terms of vibration. What is the variation in this vibration? What are the extremes in terms of the maximum and minimum vibration?
A1.4	Define the physical environment in which the role will be performed in terms of surrounding ambient pressure. What is the variation in this pressure over short and long periods? What are the extremes in terms of the maximum and minimum ambient pressure?
A1.5	Define the physical environment in which the role will be performed in terms of noise level (continuous and intermittent), i.e. undesired sound. What is the variation is this noise level? What are the extremes in terms of the maximum and minimum noise level? What are the noise sources?
A1.6	Define the physical environment in which the role will be performed in terms of air pollutants that might be present (continuous or intermittent). What is the variation in air pollutants and their maximum and minimum concentration in the atmosphere?
A1.7	Define the physical environment in which the role will be performed in terms of relative humidity. What is the variation in relative humidity? What are the extremes in terms of the maximum and minimum relative humidity? Is the relative humidity controllable, and, if so, what factors determine the set level?

ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

A1. ROLE CHARACTERISTICS

A1.8	Define the physical environment in which the role is to be performed in terms of air movement (speed and rate of change in an enclosed environment). What are the maximum and minimum values?
A1.9 (a)	Is the ambient lighting natural and/or artificial? What is the ambient lighting level, does this vary throughout a 24 hour period according to a set pattern? Can the lighting level be varied manually?
A1.9 (b)	What is the main colour scheme of the environment?
A1.10	Will performing the role cause an adverse change to any of the above environmental factors? If so, how and to what extent?
A1.11	Is the environment in which the role is performed stimulating or monotonous?
A1.12	Is the role performed under extreme changes in environmental conditions?
A1.13	Define the type and extent of distractions and interruptions that might be expected from the environment.
A1.14	Define the environment in terms of potential chemical hazards.
A1.15	Define the environment in terms of potential physical hazards.
A1.16	Define the environment in terms of potential biological hazards.
A1.17	What are the potential chemical hazards that are introduced as a result of performing the role
A1.18	What are the potential physical hazards that are introduced as a result of performing the role?
A1.19	What are the potential biological hazards that are introduced as a result of performing the role?
A1.20	Define the workstation/site in which the role is performed in terms dimensions and layout? Who or what determined the dimensions and layout? If the workstation/site is designed for human activity, is there a design standard?

A1.20 Contd.	Can the workstation/site be adjusted to suit different individuals of different dimensions?
A1.21	Where is the workstation/site located, e.g. at height, over the side of the platform, within a confined, enclosed or congested space?
A1.22	Are other activities outwith those associated with the role carried out at the same workstation/site?
A1.23	What is the duty pattern associated with the role (i.e. what is the minimum, average and maximum number of hours one person might be expected to be on duty in a 24 hour period and how many days would such a duty extend)?
A1.24	Is the role performed by more than one person to give continuous attendance with respect to time? If so, define the resultant shift schedule associated with the role? The following terminology has been used in the questions given under A1.24: shift — the time of day on a given day that a role holder is scheduled to be at the workstation/site, off time — hours not normally required to be at the workstation/site, schedule — sequence of consecutive shifts and off time, permanent hours — schedule that does not require the role holder to work more than one shift (the time of day worked is constant), rotating hours — schedule that requires the rôle holder to work more than one shift (the time of day worked changes), basic sequence — minimum number of days of shift and off days until a sequence begins to repeat. What is the basic sequence of the shift schedule? What is the normal total number of hours within each shift? What is the maximum total number of hours within each shift? What are the times of each shift in the shift schedule?

A1. ROLE CHARACTERISTICS

A1.24 Contd.	What is the normal number of consecutive shifts in a schedule? What is the maximum number of consecutive shifts in a schedule? What is the minimum, average and maximum total number of hours on shift in any preceding week ? Is the shift pattern irregular? Is there a changeover within the shift schedule, e.g. days to nights or vice versa. and how is it performed? What are the shift handover times and duration, and how is this performed? What is the maximum number of hours possible between consolidated sleep What is the minimum number of hours consolidated sleep? What determines the timing of such sleep? What contingency exists to manage situations where there is no relief of a role holder either at the end of a shift or at the end of a shift schedule.
A1.25	How many accommodation musters would be expected between the hours 0600 to 1800 hrs and 1800 to 0600 hrs during a production period on the platform?
A1.26	How many accommodation musters would be expected between the hours 0600 to 1800 hrs and 1800 to 0600 hrs during a high activity period on the platform (such as an annual shutdown for maintenance)?
A1.27	Define the sleeping environment in terms of temperature, pressure, relative humidity, noise level (continuous and intermittent), distractions, and air movement.
A1.28	Define how an individual is selected for the role in terms of personality attributes. Is account taken of whether the individual who performs the role is to work in isolation or as part of a team?
A1.29	How are the fitness requirements for the role determined?

A1. ROLE CHARACTERISTICS

A1.29 Cont.	What are the fitness requirements for the role, e.g. muscle build, hearing ability, absence of colour blindness? What screening exists to determine fitness to work (psychological and physical)? Is the screening performed once as part of the recruitment process or periodically whilst the role holder is in the position? Does such screening test for drugs and alcohol abuse? Is there control of common non prescribed and prescribed drugs? How are transient illnesses such as colds and influenza handled?
A1.30	When and what food (including caffeine and alcohol) is available to the role holder?
A1.31	Is the age of the role holder taken into account with respect to psychological and physical abilities?
A1.32	What is the minimum and maximum time any individual is assigned to the role?
A1.33	What cover is available should the role holder not be available to perform the role for a given time period? How is a person to cover selected and trained? What assessment and reassessment is made to ensure the cover is competent in knowledge, skills, fitness etc.?
A1.34	Is account taken of the time of day a role holder will or could be required to perform a particular task?
A1.35	What system of recognition exists to reward good performance?
A1.36	What contingencies exist to assist a role holder who has domestic problems?
A1.37	Are an individual's language and communication skills assessed with respect to the requirements to perform the role?

ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

A1. ROLE CHARACTERISTICS

A1.38	Does a sub culture exist associated with the role? Are there any superstitions associated with the role?
A1.39	Define the type and extent of distractions and interruptions, e.g. irrelevant speech, ad hoc phone calls, visitors to platform, that might be expected within the role from other people?
A1.40	Is the potential impairment from social psychological factors recognised and addressed within the working environment? Such factors include isolation from home and relatives; the relationships between the role holder and his or her peers; supervisor and sub-ordinates; group membership; culture and society norms; group norms of behaviour; group pressure and conformity; coercion; and conditioning.
A1.41	How is the Company organised to support the role holder?
A1.42	Do external pressures (Company, supervisors, peer group) to meet deadlines and perform exist?
A1.43	Does the role holder undergo annual appraisal and ranking against others?
A1.44	Where the role involves working as part of a team, what is the age and experience of other persons in the team?
A1.45	What are the irritants associated with the role, e.g. excessive quantities of irrelevant paper, electronic messaging, travel delays, excessive standards and procedures, equipment failure, repetitive false alarms and incorrect data, lack of private space?

ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

B1. ROLE REQUIREMENTS

The role requirements are defined as the requirements to perform the role.

B1.1	What is the role title?
B1.2	What is required from the role according to the job description?
B1.3	What is required from the role according to those who perform the role?
B1.4	What is the total number of tasks within the role according to those who perform the role? Provide a one line description for each task. Will any of the tasks result in conflicting responsibilities?
B1.5	Which of the tasks are perceived to be stimulating by the individual who performs the role?
B1.6	Which of the tasks are perceived as monotonous by the individual who performs the role?
B1.7	Identify each task which has been termed a safety critical task (from task analysis if applicable).
B1.8	Under what circumstances are the safety critical tasks performed, i.e. normal conditions, abnormal conditions or emergency conditions?
B1.9	Which of the safety critical tasks can be planned, and which will be unplanned?
B1.10	What factors decide the timing to perform a safety critical task and the task deadlines?
B1.11	Are the safety critical tasks supervised and to what degree?
B1.12	What are the requirements for situational awareness (risk perception) for each of the safety critical tasks performed within the role?
B1.13	Do any of the safety critical tasks within a role necessitate command or supervision of others?

B1. ROLE REQUIREMENTS

B1.14	What is the maximum duration of the safety critical tasks within the role? Do any of the safety critical tasks require periods of vigilance?
B1.15	Do any of the safety critical tasks allow an individual to take rest breaks during their execution? How long are the rest breaks and of what do they consist?
B1.16	Do any of the safety critical tasks require a toolbox talk?
B1.17	What safety critical tasks require the completion of documentation prior to their commencement (e.g. Permit to Work)?
B1.18	Does the role require knowledge of terminology, slang, etc.?
B1.19	Does the role require fluency in the working language in order to command persons in an emergency situation?
B1.20 (a)&(b)	Taking each safety critical task in turn, what information is required and what is available to perform the tasks within the role?
B1.20 (c)	How is this information presented to the individual, e.g. verbally (directly or via telephone or radio), audibly via an alarm system, visually via gauges, computer monitor or status lights, written etc.?
B1.20 (d)	Are gauges etc. selected for ease of readability by those who will be using them?
B1.20 (e)	Are any of the controls unusual in terms of operation?
B1.20 (f)	Is any of the information colour coded? If so, what do the colours (e.g. yellow (amber), red, green, blue, white, other) represent?
B1.20 (g)	Is all information presented visually within the individual's field of vision from the normal work position?
B1.20 (h)	What is the quality of the information, is it reliable? Do any of the information sources have error which has to be corrected by the individual?

B1. ROLE REQUIREMENTS

B1.20 (i)	Is all necessary information readily accessible?
B1.20 (j)	Is there any information which is inferred from available information?
B1.20 (k)	What controls the timing of when information is presented? Is this information then available continuously or only for a short period of time?
B1.21	What is the maximum amount of information an individual would be expected to process at any one time: under normal situations?; abnormal situations?; and emergency situations?
B1.22	Does the role involve periods of underload which can be broken by the sudden requirement to respond to a high workload?
B1.23 (a)	What safety critical tasks require use of mentally held knowledge and/or a skill or number of skills and to what extent? How is such knowledge and/or these skills acquired, e.g. acquired elsewhere, acquired 'on the job' or by specific training with an assessment process to determine whether the skill(s) have been acquired and maintained?
B1.23 (b)	Is information obtained from the investigation of incidents used in a training programme as part of knowledge and skill acquisition?
B1.23 (c)	Where skills are tested and assessed, how is the test and assessment determined to be a valid predictor of performance in the 'on the job'?
B1.23 (d)	Where skills are assessed, how are the assessors selected and assessed?
B1.23 (e)	Is the knowledge acquired during training tested in practical applications?
B1.23 (f)	Is there any monitoring of performance 'on the job' after training?
B1.24	Are individuals trained in diagnostic, problem solving and decision making skills which will help them to cope with unfamiliar situations?
B1.25	Are infrequently used but important knowledge and skills given frequent refresher training?

ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

B1. ROLE REQUIREMENTS

B1.26	Do any of the safety critical tasks involve the interpretation and mental manipulation of information or for information to be held for any length of time in the individual's memory between receipt and usage?
B1.27	Does the role require periods of passive monitoring and/or observation in isolation which are greater than half an hour?
B1.28	Do the safety critical tasks require sustained attention (concentration) for long periods of time (greater than one hour)?
B1.29	For all safety critical tasks, to what extent is information transmitted verbally between individuals (including during a handover of information)?
B1.30	Are there clear procedures for the handover of information and responsibility between different shifts and/or individuals with different responsibilities, e.g. operations and maintenance?
B1.31	For each safety critical task, what procedures and checklists exist to perform each of the tasks in the role? Who wrote these documents and how is it ensured that users understand the text? Where misunderstanding or ambiguity is identified, how is this corrected?
B1.32	Is the range of applicability of the procedures and checklists documented and identified to the users?
B1.33	Are the conditions under which the procedures must be used clear and unambiguous to the users? How are such tested?
B1.34	Is there a simple and unambiguous indexing method for users to choose the required procedures in all foreseen situations? How is such tested?
B1.35	Has the use of the provided procedures been tested 'on the job'?
B1.36	Is there a system for revising procedures in the light of experience?
B1.37	Can emergency procedures be implemented whether or not the user knows what is wrong, i.e. are they symptom based rather than event based?

B1. ROLE REQUIREMENTS

B1.38	What problems solving might the individual be required to perform in the execution of each of the safety critical tasks?
B1.39	What decision making might the individual be required to perform in the execution of each of the safety critical tasks?
B1.40	What is the minimum time for making a decision within the safety critical tasks? How accurate do such decisions need to be?
B1.41	Do the safety critical tasks require decisions to be made alone or part of a team?
B1.42	In teams, is the allocation of responsibility and authority clear, complete, non overlapping, known to and accepted by all individuals including the role holder(s)?
B1.43	Are any changes in these responsibilities during a non routine event or emergency clear and practised?
B1.44	Does the role include repetitive safety critical tasks? If so, what is the work and its frequency, e.g. number of times per 12 hours, number of days per week, etc.?
B1.45	Do any of the tasks required to be performed under the role necessitate physical (manual) work? What is the extent and nature of it this work?
B1.46 (a)	For any manual work that is performed: What type of work is involved, i.e. static or dynamic physical effort, and over what time period (endurance)? Is any of the movement repetitive, e.g. number of times per day, number of days per week? What is the duration of any applied physical effort? Does any movement involve excessive joint angles? Does the movement require rapid bursts of activity or activity at a steady rate over a longer period of time?

B1 ROLE REQUIREMENTS

B1.46 (a) Contd.	Are people assigned to the task(s) based on some measurement of physical capability? How is the measurement determined to be a valid measurement of an individual's capability?
B1.46 (b)	For manual handling (lifting) tasks in particular: What is the frequency of the lifting task(s)? What is the distance over which the load is carried? What is the time for which the load is supported by an individual? What is the weight of the load? Is the lifting operation performed by one individual? What is the height at the start of the lift? What is the height at the end of the lift? Is any training performed on how to lift? What does the training consist of and what lifting technique is taught? Is the workspace to perform the lift restricted (restricting posture)? Does the load have handles and, if so, where are they located? What is the size and shape of the object to be lifted? Under what conditions is the manual handling performed, e.g. transport up and down stairs, on floors which might be slippery, exposed locations where gusting winds might be experienced?
B1.47	What tools are available to perform the tasks within the role (including handheld tools, computers, cranes etc.)? Are any of the tools used similar but not identical in operation, e.g. computer consoles, control panels?

ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

B1 ROLE REQUIREMENTS

B1.47 Contd.	Do any of the tools generate vibration of the user' limbs etc.? Are the tools periodically checked and maintained? What training is given in the use of the tools? Are any of the tools unusual in terms of operation or usage, e.g. handles turn clockwise for OFF and decrease or turn anti-clockwise for ON or increase?
B1.48	Do any of the tasks require the use of personal protective equipment? What personal protective equipment is required? Can this equipment restrict movement, field of vision or the individual's heat maintenance?
B1.49	What support organisation is required to perform the tasks within the role?

A2. HUMAN CHARACTERISTICS

The human characteristics are defined as the properties of the human being as opposed to his or her requirements to perform the role. The characteristics are as a result of the psychological, physiological and physical properties of human beings.

The following gives an outline of why a particular (role characteristic) factor is important to consider. However it is important that the actual effect a factor, or combination of factors, has is determined at the workplace as well as in isolation under controlled conditions and using the people who perform the role as certain factors have been shown to have task, age and gender variations and to interact with other factors.

A2.1

Define the physical environment in which the role will be performed in terms of ambient temperature. What is the variation in this temperature. What are the extremes in terms of maximum and minimum temperature.

For a given situation, an individual's response to heat will be dependent upon ambient conditions of temperature, humidity, air velocity and radiation; the amount and type of clothing being worn (including PPE), the nature of the task; the severity of the work rate and its duration; and the physiological and physical characteristics and fitness of the individual. An individual will gain or loss heat as a result of his or her metabolism and physical work, and the convection, radiation and conduction of heat with the environment.

In the consideration of ambient temperature, humidity and wind speed, it is important to consider not only the normal value but also to consider the possible extremes to which an individual might be subjected.

People can physiologically survive a wide range of environmental temperatures providing that they have the correct protective clothing and equipment; however it is when an individual's core (deep) temperature varies that human failure can result. An individual (by sweating when hot, adding or removing clothing, shielding or moving away from a radiant heat source etc.) behaves to maintain a core temperature of approximately 37°C. An increase in core temperature of 3 - 4°C can lead to a deterioration in mental and physical performance, confusion, unconsciousness, coma and possible death. A decrease in core temperature can lead to impaired judgement (36°C), personality change (withdrawal), confusion, stumbling and falling (34°C) and unconsciousness (31°C). In most circumstances an individual will be aware that he or she is hot or cold and their behaviour will be to limit the effect, however where this is not possible, human failure can result. An extreme example of this is divers who require to breathe cold gas. The cold gas decreases core temperature but skin temperature remains normal and the diver is unaware of the core temperature decrease. The environmental temperature can also have indirect effects such as dehydration (which can result from an increase or decrease in temperature) which can also impair performance.

In terms of mental, intellectual and manual performance, the determination of the deterioration in such as a function of ambient temperature alone is not always possible because of the number of associated factors as highlighted above.

A2. HUMAN CHARACTERISTICS

A2.1 Contd.	However research indicates that, as a general rule for elevated temperatures, a deterioration in mental and intellectual performance is observed when the ambient temperature exceeds 25°C where the individual is unacclimatised to heat and 30 to 35°C where the individual is acclimatised to the heat. Other research has indicated that both ambient temperature and time of exposure can affect mental performance (including vigilance) with high temperature causing greater impairment than increasing exposure time at a given lower temperature. Research that measures core temperature suggests that it is the change in the individual's core temperature which is associated with the impairment in vigilance. The effects of low temperature on mental and intellectual performance are less well researched and such research has not been able to provide a general rule for minimum temperatures below which impairment in performance results. Research that has been carried out, however, suggests ambient conditions which cause a lowering of the skin temperature below the normal value of 34°C impairs mental dexterity and fine motor control and that low temperature causes distraction rather than a direct effect on the nervous system. Whilst other research suggests that it is not just an issue of distraction but also of the level of arousal. At very low temperatures, the level of arousal is high which impairs performance. In terms of manual performance, research indicates that there is a general increase in performance up to an ambient temperature of 32°C. Performance drops as this temperature increases beyond 32°C up to 38°C (the maximum temperature studied). This research was performed on acclimatised individuals and so may not be representative for non acclimatised persons. Where there is concern that ambient conditions could impair mental, intellectual and/or manual performance, an assessment at the worksite should be made using actual core temperature measurement and performance measurement, or available heat stress or comfort indexes. The measurements should be made by a qualified professional (e.g. ergonomist, occupational hygienist). The following is a summarised general guideline for thermal comfort conditions: ambient temperature (as measured by a dry bulb thermometer) should be in the range 19.4 - 22.8°C for sedentary work; 15.6 - 20°C for light manual work and 12.8 - 15°C for heavy manual work; relative humidity should be in the range 50 - 60% RH; radiant temperature (as measured by a black globe thermometer) should be in the range 16.7 - 20°C for light manual work with an optimum air movement of 0.15m/s (less than 0.10 m/s is perceived as 'airless'). The American Conference of Governmental Industrial Hygienists (1976) has more detailed limit values for industrial application, based on an index known Wet Bulb Globe Temperature Index. The limit values are based on the assumption that almost all acclimatised and fully clothed workers with an appropriate fluid and salt intake should be able to work under the limit values without their core temperatures rising above 38°C.

A2.1 Contd.	Further reading: Smith, A.P., and Jones, D.M., (1992) Handbook of Human Performance, Vol. 1 The Physical Environment, pp. 79-130, London, Academic Press Ltd., for details of current research on human performance in hot and cold environments. BS 7179 (1990) Ergonomics of design and use of visual display terminals (VDTs) in offices, Part 6, Code of practice for the design of VDT work environments. Tests: Psychological, Physiological, Physical.
A2.2	*Define the physical environment in which the role will be performed in terms of ambient radiative heat temperature. What is the variation in this temperature. What are the extremes in terms of the maximum and minimum radiative heat temperature.* See A1.1.
A2.3	*Define the physical environment in which the role will be performed in terms of vibration. What is the variation in this vibration. What are the extremes in terms of the maximum and minimum vibration.* The effect of vibration on mental and physical performance is little understood, particularly the cumulative effect of vibration with other stressors (e.g. noise). There is, however, reasonable evidence to suggest that working in vibrating environments for any length of time affects both visual and manual control performance and hence affects the potential for human failure. Working in vibrating environments can also cause physical discomfort and interfere with verbal communication. The actual psychological, physiological and physical effects of vibration on the human body depend on the acceleration, frequency, amplitude, exposure time and whether the vibration is continuous or intermittent with rest breaks. The direction of the vibrating forces applied to the body determines the actual sensory and psycho-physiological reactions to the motion. An assessment should be made at the worksite to determine the effects of vibration on performance where such exists. Further reading: Smith, A.P., and Jones, D.M., (1992) Handbook of Human Performance, Vol. 1 The Physical Environment, pp. 55-78, London, Academic Press Ltd., for details of current research on human performance and vibration. Tests: Psychological, Physiological, Physical.

A2.4	*Define the physical environment in which the role will be performed in terms of surrounding ambient pressure. What is the variation in this pressure over short and long periods. What are the extremes in terms of the maximum and minimum ambient pressure.* Mental and physical performance at low ambient pressure (e.g. high altitude), is impaired although there is some evidence to suggest that individuals can acclimatise to the reduced pressure. Humans are not, however, able to acclimatise to high pressure. Exposure to very high pressure environments, such as those experienced by divers can give rise to impairment in mental performance and physiological and physical problems such as the following: tremor at 15 atm; muscle spasms, dizziness, epigastric discomfort, nausea and stomach cramps at 20 atm; and EEG changes and sleep disturbances at 30 atm. The onset of such is hastened by fast compression and delayed by slow compression. At 40 atm, hallucinations can occur. All can affect performance. The effect of pressure changes which involve the individual moving from a 'high' to a 'lower' pressure environment on the potential for human failure are generally associated with divers and the release of tissue and blood gases in solution. Such is well covered elsewhere, however working in an environment of slightly elevated pressure, e.g. pressurised modules, and movement to a lower pressure environment can cause discomfort and pain as gases expand in the gut. The discomfort and pain can cause distraction and hence affect performance on a task. Further reading: Smith, A.P., and Jones, D.M., (1992) Handbook of Human Performance, Vol. 1 The Physical Environment, pp. 177-209, London, Academic Press Ltd., for details of current research on human performance in hyperbaric environments. Tests: Psychological, physiological, physical.
A2.5	*Define the physical environment in which the role will be performed in terms of noise level (continuous and intermittent), i.e. undesired sound. What is the variation is this noise level. What are the extremes in terms of the maximum and minimum noise level. What are the noise sources.* Noise is generally thought of as an unwanted sound. The human ear is differentially sensitive to different pitches in the range 20 Hz to 20000 Hz. From approximately 19 years of age onwards there is a loss of sensitivity to the top range resulting in an audible pitch range of approximately 20 to 15000 Hz.

A2.5 Contd.

The physical effects of noise can be as follows: temporary deafness, caused by short exposure to a very loud noise; permanent deafness, caused by lengthy exposure to a very loud noise or short exposure to an extremely loud noise; exposure to broadband industrial noise (i.e. a number of frequencies), causes a loss of sensitivity in the range 4000 - 5000 Hz.

The effects of noise on performance can include an inability to perceive verbal instructions and audible alarms, loss of concentration and, as research has indicated, a measured deterioration in performance in certain tasks under certain conditions.

Noise bursts have also been shown to impair performance in certain tasks where such noise bursts occur over a short period of time.

There have been a number of field studies in real life environments in support of the research findings which were observed in controlled environments. One such field study found that noise level in a factory was related to accident frequency (but not to the severity of the accident). Another such study observed that not only were accidents more frequent in an environment where there was noise, but also that young, less experienced workers were more likely to have accidents. The suggestion being that noise affects high mental workload which is a characteristic of the young inexperienced workers.

The conclusions from the above research and other work in this area are that noise can impair performance, but the precise effect is complex and depends on the nature of the noise, the characteristics of individuals exposed to the noise, and the task(s) being performed; and that investigation is required for each particular set of circumstances.

Research has also indicated that noise can interact with other factors such as nightwork and heat. This suggests that where noise exists in an environment it is important to study its effect, not just in isolation, but in the presence of the other human factors.

Further reading: Smith, A.P., and Jones, D.M., (1992) Handbook of Human Performance, Vol. 1 The Physical Environment, pp. 1-28, London, Academic Press Ltd., for details of current research on human performance and noise (including irrelevant speech).

Tests: Psychological, physiological.

A2. HUMAN CHARACTERISTICS

A2.6	*Define the physical environment in which the role will be performed in terms of air pollutants that might be present (continuous or intermittent). What is the variation in air pollutants and their maximum and minimum concentration in the atmosphere.* The main research on the effect of air pollution on human performance to date is associated with the effects of carbon monoxide, oxides of sulphur and nitrogen, particulates and ozone. In general, an excess of any pollutant is generally considered to be detrimental to health and affect performance. Further reading: Smith, A.P., and Jones, D.M., (1992) Handbook of Human Performance, Vol. 1 The Physical Environment, pp. 131-138, London, Academic Press Ltd., for details of current research on human performance and air pollution.
A2.7	*Define the physical environment in which the role will be performed in terms of relative humidity. What is the variation in relative humidity. What are the extremes in terms of the maximum and minimum relative humidity. Is the relative humidity controllable, and, if so, what factors determine the set level.* See A1.1.
A2.8	*Define the physical environment in which the role is to be performed in terms of air movement (speed and rate of change in an enclosed environment). What are the maximum and minimum values.* See A1.1.
A2.9	*Is the ambient lighting natural and/or artificial. What is the ambient lighting level, does this vary throughout a 24 hour period according to a set pattern. Can the lighting level be varied manually.* The extent to which lighting affects human performance will depend upon the visual demands of the task and the environment in which the task is performed. Insufficient lighting can impair performance, cause discomfort and drowsiness. Too much lighting (greater than 1000 lux) can also impair performance and cause discomfort due to excessive reflections, glare, shadows etc. Lighting can also cause human failure where it is too low for individuals to detect hazards in the environment which otherwise could have been avoided.

A2.9 Contd.	An illumination range of 500 - 700 lux is recognised as appropriate for general office purposes. The British Standard BS 7179 (1990) Ergonomics of design and use of visual display terminals (VDTs) in offices, Part 6, Code of practice for the design of VDT work environments provides guidance on the quality and quantity of light for visual display terminal work and states that the general level of illuminance should be in the range 300 to 500 lux as measured horizontally at the work surface height. Research has indicated, however, that in environments where there exists a mixture of VDU work and other activities, such as in control rooms, individuals prefer illuminances of 250 - 300 lux. ISO8995 and BS8206 gives further recommendations for lighting levels under different applications. An artificial lighting system which is not perceived to vary in intensity by an individual may contribute to the monotony of an environment and hence may affect performance (see A2.11). One which cannot be controlled manually may cause discomfort to certain individuals. Further reading: BS 7179 (1990) Ergonomics of design and use of visual display terminals (VDTs) in offices, Part 6, Code of practice for the design of VDT work environments. Pheasant, S., (1991) Ergonomics, Work and Health, London, Taylor and Francis. Tests: Psychological.
A2.10	*Will performing the role cause an adverse change to any of the above environmental factors. If so, how and to what extent.* It is important to consider whether performing the tasks within a role will cause an adverse change in any of the above environmental conditions, and to what extent. Where the individual is also required to work under such conditions then these transient conditions also need to be considered in terms of their possible effect on human performance. Tests: Psychological, physiological, physical.
A2.11	*Is the environment in which the role is performed stimulating or monotonous.* A monotonous environment where there is very little movement and change, little activity and/or dull lighting can impair human performance as an individual in such an environment can become bored and inactive. Human failure can result particularly if the individual is suddenly required to respond to a rapidly escalating incident. Temperature, aroma and noise are also factors which affect the monotony of an environment.

A2.11 Contd.	There will be individual variations in what people perceive as monotonous and it is important that the perception of the role holder(s) is established. The monotony of an environment can compound the negative effects of other factors such as lack of sleep, and time of day on human performance and induce drowsiness. It is therefore important that then environment is as stimulating as possible to the role holder(s) (but at the same time not so stimulating that it is distractive). Where this is not possible, then the individual(s) should be able to take breaks from the environment or periodically perform work which is stimulating. Tests: Psychological.
A2.12	*Is the role performed under extreme changes in environmental conditions.* The effect of extreme changes in environmental conditions on human performance should be considered. For example the effect where a role necessitates individuals to move repeatedly from high and low temperatures needs to be investigated to determine its effect on human performance and the potential for human failure.
A2.13	*Define the type and extent of distractions and interruptions that might be expected from the physical environment.* Distractions and interruptions from the physical environment will affect performance by distracting attention and breaking concentration. The full extent of distractions and interruptions (e.g. those that arise from the weather, noise, alarms, smells) should be addressed and minimised where possible.
A2.14	*Define the environment in terms of potential chemical hazards.* The potential chemical hazards to human beings are from gases, vapours, aerosols, liquids and solids (dusts and powders). Where such exist or are emitted into the atmosphere, there is the potential for human failure as a result of disease and damage to: the brain (organic solvents, alcohol, heavy metals), the lungs (sensitizers, mineral dusts, fumes and gases), the skin (drying agents, irritants, carcinogens), the nose (sensitizers, carcinogens) and the liver, kidneys and bladder (absorbed chemicals). Further reading: Control of Substances Hazardous to Health (COSHH) and Control of Carcinogenic Substances Regulations.

A2.14 Contd.	American Conference of Governmental Industrial Hygienists (ACGIH) (US). Tests: Psychological, physiological, physical.
A2.15	*Define the environment in terms of potential physical hazards.* The potential physical hazards to human beings are from heat, cold, noise, vibration, ionising and non ionising radiation, external forces and loads. Where such exist, there is the potential for human failure as a result of disease and damage to: the musculo-skeletal system (from external forces and loads), skin (UV and IR light, ionising radiation), nose and lungs (ionising radiation), eye (radiant heat and light) and ears (noise). Other potential physical hazards include objects which can be impacted with, stairs, oil and grease present on floors etc. which can constitute a tripping or slipping hazard, temporary placement of cables and objects in access routes etc. machinery and equipment which is unshielded, working at height or falling overboard. Tests: Psychological, physiological, physical.
A2.16	*Define the environment in terms of potential biological hazards.* The potential biological hazards to human beings are from infectious agents, and allergenic particles such as pollen. Further reading: Control of Substances Hazardous to Health (COSHH) Regulations. Tests: Psychological, physiological, physical.
A2.17	*What are the potential chemical hazards that are introduced as a result of performing the role.* Chemical hazards can be introduced as a result of performing the role. The effect of hazards that are introduced as a result of carrying out tasks within the role should also be considered and their potential impact on the human assessed. Further reading: Control of Substances Hazardous to Health (COSHH) Regulations. Tests: Psychological, physiological, physical.

A2.18	*What are the potential physical hazards that are introduced as a result of performing the role.* Physical hazards can be introduced as a result of performing the role. The effect of hazards that are introduced as a result of carrying out tasks within the role should also be considered and their potential impact on the human assessed. Tests: Psychological, physiological, physical.
A2.19	*What are the potential biological hazards that are introduced as a result of performing the role.* Biological hazards can be introduced as a result of performing the role. The effect of hazards that are introduced as a result of carrying out tasks within the role should also be considered and their potential impact on the human assessed. Further reading: Control of Substances Hazardous to Health (COSHH) Regulations. Tests: Psychological, physiological, physical.
A2.20	*Define the workstation/site in which the role is performed in terms dimensions and layout. Who or what determined the dimensions and layout.* *If the workstation/site is designed for human activity, is there a design standard.* *Can the workstation/site be adjusted to suit different individuals of different dimensions.* Consideration should be given to how the workstation/site was designed and whether it was based on an assessment of the tasks which were to be performed at the site and how the role holder will require to move and operate equipment and have access to equipment etc. A workstation/site which is not compatible with human interaction can provide the potential for human failure. Due to the variability in human dimensions, height, reach etc., it is important that work surfaces, seating, etc. is adjustable to suit individual requirements. Where furniture height is not adjustable, it is important to establish whether the installed height was based on anthropometric data (i.e. the physical measurement off human dimensions and movement) for a given population and whether the dimensions are suitable for the population of people who will be using the facilities.

A2.20 Contd.	Where facilities are fixed and are inappropriate for the dimensions of the users, apart from discomfort which can affect concentration, the potential for human failure in terms of injury such as back injury and repetitive strain injury (upper limb disorder) will exist. It is important to consider all tasks that might be performed at the workstations (intended and actual) when considering the design and layout of any facilities. Further reading: British Standards Institute, BS7179 (1990), Ergonomics of design and use of visual display terminals (VDTs) in the offices, Part 5, Specification for VDT workstations. The Health and Safety Executive (1992), Display screen equipment work, Guidance on Regulations. Tests: Physical.
A2.21	*Where is the workstation/site located, e.g. at height, over the side of the platform, within a confined, enclosed or congested space.* See A2.20. Work at such locations should also take into account possible phobias that the role holder(s) might have with respect to height, enclosed spaces etc. and the effect this might have on concentration and the potential for human failure. Tests: Psychological, physical.
A2.22	*Are other activities outwith those associated with the role carried out at the same workstation/site.* The workstation/site should be suitable for all intended tasks that are performed there.
A2.23	*What is the duty pattern associated with the role (i.e. what is the minimum, average and maximum number of hours one person might be expected to be on duty in a 24 hour period and how many days would such a duty extend).* The potential effect of an individual whose duties include call out outwith recognised working hours should be assessed, particularly where sleeping hours are disturbed.
A2.24	*Is the role performed by more than one person to give continuous attendance with respect to time. If so, define the resultant shift schedule associated with the role. The following terminology has been used in the questions given under A2.24:*

A2.24 Contd.

shift	*the time of day on a given day that a role holder is scheduled to be at the workstation/site,*
off time	*hours not normally required to be at the workstation/site,*
schedule	*sequence of consecutive shifts and off time,*
permanent hours	*schedule that does not require the role holder to work more than one shift (the time of day worked is constant),*
rotating hours	*schedule that requires the role holder to work more than one shift (the time of day worked changes),*
basic sequence	*minimum number of days of shift and off days until a sequence begins to repeat.*

What is the basic sequence of the shift schedule.

What is the normal total number of hours within each shift.

What is the maximum total number of hours within each shift.

What are the times of each shift in the shift schedule.

What is the normal number of consecutive shifts in a schedule.

What is the maximum number of consecutive shifts in a schedule.

What is the minimum, average and maximum total number of hours on shift in any preceding week.

Is the shift pattern irregular.

Is there a changeover within the shift schedule, e.g. days to nights or vice versa. and how is it performed.

What are the shift handover times and duration, and how is this performed.

What is the maximum number of hours possible between consolidated sleep.

What is the minimum number of hours consolidated sleep. What determines the timing of such sleep.

What contingency exists to manage situations where there is no relief of a role holder either at the end of a shift or at the end of a shift schedule.

A2.24 Contd.	Shift work can affect human performance and cause fatigue. The effect of shift work on human performance is closely tied in with research into the circadian rhythms of the human body (i.e. biological rhythms which have a 24-28 hours cycle), particularly body temperature, and how these rhythms and their peaks and troughs affect performance. There is evidence to suggest that the peaks and troughs of shift workers can shift with respect to time whilst these workers maintain the abnormal hours of work and sleep. This and other research associated with the type of tasks performed on shift, has led to the claim that, in terms of optimum human performance, mental tasks require a different shift pattern than manual tasks. A shift pattern inconsistent with the type of work performed can therefore increase the potential for human failure. Shift work can also affect the health of individuals. It would appear that there is a higher rate of cardiovascular disease and gastrointestinal disorders amongst shift workers than people who work the traditional 'office' hours. There are some people who are unable to adapt to shift work altogether and develop what is known as 'shift maladaption syndrome' characterised by two or more medical conditions from a list which includes chronic sleep disorder, gastrointestinal disorder, cardiovascular disorder and mood disorder. The questions above exist to determine the extent to which an individual is required to adjust to an 'abnormal' pattern of work and sleep and the extent to which sleep is interfered with. These factors can both increase the potential for human failure and need to be investigated and minimised where shift work exists. Further reading: Moore-Ede, M.C. and Richardson, G.S. (1985) Shift Maladaption Syndrome, Annual Review of Medicine, 36, pp. 607-617. Tests: Psychological, physiological, physical.
A2.25	*How many accommodation musters would be expected between the hours 0600 to 1800 hrs and 1800 to 0600 hrs during a production period on the platform.* The potential effect of an accommodation muster is the disturbance of an individual's sleep period and his or her return to sleep. Although individual variations are likely, it is important to investigate the effect this might have on performance, particularly where the number is excessive. Since there will be people sleeping through daylight hours as well as night time, it is important to study both time periods. Sleep deprivation will make people tired and irritable, disrupt the individual's circadian rhythms, and increase the potential for human failure. Research indicates that sleep deprivation can become a significant factor in human performance, at least for daytime work, when an individual receives less than five hours sleep per night over a period of time. Performance impairment can be reduced if napping is possible. However the benefits of a daytime nap will depend

A2.25 Contd.	greatly on when the nap is taken, its quality, its duration and the amount of sleep deprivation an individual has experienced. There is also evidence to suggest that the benefits of napping, during the daytime or night time, are only observed two hours after the nap and that performance can actually be worse immediately after the nap (especially if the nap is taken at night). Further reading: Dinges DF, Orne MT and Orne EC, 1985, Assessing performance upon abrupt awakening from naps during quasi continuous operations. Behaviour Research Methods, Instruments and Computers, 17, 37-45. Tests: Psychological, physiological, physical.
A2.26	*How many accommodation musters would be expected between the hours 0600 to 1800 hrs and 1800 to 0600 hrs during a high activity period on the platform (such as an annual shutdown for maintenance).* As A2.25.
A2.27	*Define the sleeping environment in terms of temperature, pressure, relative humidity, noise level (continuous and intermittent), distractions, and air movement.* The environment in which an individual sleeps can affect the quality of his or her sleep and, as a result, affect mental and physical performance during waking hours. A sleeping environment which is too hot, too cold, too low in humidity, or too noisy, for example, will deprive an individual of sleep even if there is five hours minimum (see A2.25) to sleep. Investigation is required to determine what constitutes the optimum sleeping environment for the people concerned. Due to individual variations, the environment should be adjustable to an extent which can accommodate these individual variations. Tests: Psychological, physiological, physical.
A2.28	*Define how an individual is selected for the role in terms of personality attributes. Is account taken of whether the individual who performs the role is to work in isolation or as part of a team.* The personality attributes of an individual are considered to be relatively stable characteristics of that individual. The personality attributes, as measured by psychometric tests, are generally grouped into those which contribute towards interpersonal style, i.e. how the individual interacts with others; thinking style and how the individual copes with stress. The personality attributes of a role holder are important to consider since an individual who is placed in a role which is not

A2.28 Contd.	consistent with his or her personality can suffer stress, or create stress in those with whom he or she interacts. This can increase the potential for human failure. For example a person who needs to work with others will not perform well if the role requires him or her to work in isolation. Whereas if the individual is required to work as part of a team then it is important that his or her interpersonal style is consistent with such work. The tendency to risk take or adhere to rules and regulations are also measured by psychometric tests of personality and these too are important to consider when selecting an individual for a role. Tests: Psychological (psychometric tests). Note: Although psychometric tests aim to measure the relatively enduring characteristics of an individual, it is important to note that these characteristics can change with time. As a result, a psychometric test of personality is generally accepted to be a reliable assessment of personality for no longer than 6 months. After 6 months, a reassessment should be performed. Taking into account the need for periodic reassessment, psychometric tests can still provide a valuable assessment of an individual's personality, provided it is a reputable, validated test, the questions which constitute the test are answered honestly, and the results from the test are interpreted correctly by people qualified to do so.
A2.29	*How are the fitness requirements for the role determined.* *What are the fitness requirements for the role, e.g. muscle build, hearing ability, absence of colour blindness.* *What screening exists to determine fitness to work (psychological and physical). Is the screening performed once as part of the recruitment process or periodically whilst the role holder is in the position. Does such screening test for drugs and alcohol abuse.* *Is there control of common non prescribed and prescribed drugs.* A number of common drugs can impair performance and so can increase the potential for human failure. For example, research has shown that certain forms of analgesic drugs can cause impairment of human psychomotor and attentional processes which will impair performance on tasks which involve these processes. The ability of a role holder to continue with certain tasks whilst taking common drugs should therefore be established and remedial action taken if performance impairment is a possibility.

A2.29 Contd.	*How are transient illnesses such as colds and influenza handled.* Research in controlled environments indicates that upper respiratory virus infections and illnesses can impair performance and so can increase the potential for human failure. The actual effects depend on the task being carried out and the type of virus. Research also indicates that the impairment to performance was not limited to the time when the person was ill, but also occurred before and after the illness was noticeable. Further research is required on real life illnesses in real working environments to take into account the fact that many tasks are practised and familiar to the worker (unlike the tasks used in the research above) and the fact that naturally occurring (real life) illnesses are typically more severe that those researched to date. The interactive effect of these illnesses with other human factors needs also to be researched further. Further reading: Smith, A.P., and Jones, D.M. (1992) Handbook of Human Performance, Vol. 2, pp 279-318 (Prescribed Psychotropic Drugs: the Major and Minor Tranquillisers), pp 319-336 (Antidepressant Drugs, Cognitive Function and Human Performance), and pp 337-385 (The Effects of Anaesthetic and Analgesic Drugs). Tests: Psychological, physiological, physical.
A2.30	*When and what food (including caffeine and alcohol) is available to the role holder.* Research indicates that the consumption of food at breakfast time for day workers can have a positive effect on memory performance. However the consumption of food at lunch time can impair performance on tasks which require sustained attention from the worker. This impairment is transient but can still be a factor which increases the potential for human failure. This post lunch impairment on sustained attention tasks can be reduced by the presence of noise or the consumption of caffeine. The extent of the impairment could also depend on how anxious the individual is, research indicates that low anxiety subjects show a greater post lunch decline in performance than high anxiety subjects. The consumption of food at night by night shift workers has also been shown to affect an individual's performance although research in this area is more limited. From research that has been carried out, it is believed that the effects of food consumed at night are qualitatively different from the effects of food consumption during the 'normal' daytime hours. For example, one investigation observed that although noise alleviated a daytime post meal performance decline, this noise did not alleviate a night time post meal performance decline. Although more research is required in this area, it can be stated that caution should be exercised when extrapolating research into the effects of food consumption during the day time to the effects of food consumption at night.

A2. HUMAN CHARACTERISTICS

A2.30 Contd.	Although there is a need for much more research in general, it does appear that food consumption can affect human performance. Where there is a decline in performance, the potential for human failure is increased. The actual effects are more difficult to state as research to date indicates that the effects of food consumption on human performance can vary with the time of day and the task studied. However the size of the meal consumed and the composition of the food may also be important compounding variables which have, as yet, not been studied in detail. The effects of caffeine consumption have also been studied, and it appears that it can improve human performance in tasks requiring sustained vigilance when taken in moderate doses as found in some foods. It has also been reported that individuals claim that they are more alert and less drowsy when such doses of caffeine have been consumed. These apparent beneficial effects of caffeine are lost when it is consumed in excessive doses or by individuals who are sensitive to it, in such cases caffeine can cause anxiety and disturb sleep. Furthermore, adverse symptoms such as headache and mood changes can result when the caffeine is suddenly withdrawn from the diet. Research into alcohol consumption and human performance indicates that alcohol impairs performance for at least 14 hours after it was consumed. Memory and decision making performance are particularly impaired. Even alcohol consumed in small quantities can impair performance, the effects being similar in magnitude to those from fatigue, boredom, hunger, eating, many commonly prescribed drugs and a number of various other risk factors. Tests: Psychological, physiological
A2.31	*Is the age of the role holder taken into account with respect to psychological and physical abilities.* Although with age comes experience, certain human functions deteriorate. Mobility, vision and hearing can all deteriorate with age and impair an individual's performance. The age of a role holder, therefore, can not be ignored in an assessment of the potential for human failure.
A2.32	*What is the minimum and maximum time any individual is assigned to the role.* Research on a wide range of different tasks indicates that it can take up to 10 years for an individual to become an expert at a task or tasks. Research indicates that the task performance of an expert is qualitatively different from an inexperienced individual. For example, experts have better recall than less experienced individuals and form different mental representations of a problem (experts classify problems within their domain of expertise in terms of underlying principles and spend time reformulating problems during problem solving).

A2.32 Contd.	Experts also have a superior level of knowledge. Therefore, where all other factors are equal between two individuals, it should not be ignored that an individual who has held a role for less than 10 years may not perform as well as one who has held the role in excess of 10 years.
A2.33	*What cover is available should the role holder not be available to perform the role for a given time period.* *How is a person to cover selected and trained.* *What assessment and reassessment is made to ensure the cover is competent in knowledge, skills, fitness etc.* Any person who is required to cover for the role holder will require the same knowledge and skills as determined to be required for the role holder, competency assessment and reassessment of the cover individual is also required. In addition, the cover individual should be able to practice the use of his or her knowledge and skills periodically to help ensure that such do not deteriorate with time.
A2.34	*Is account taken of the time of day a role holder will or could be required to perform a particular task.* An individual's performance is not constant but can vary with the time of day. Such variation is believed to be due to an individual's circadian rhythms and to other 'external' factors such as the consumption of food at particular times (see A2.30). Research in controlled environments indicates that the time of day can affect human performance on both memory and perceptual motor tasks. This work is also supported by studies in the real world. Further reading: Smith, A.P. and Jones, D.M. (1992) Handbook of Human Performance, Vol. 3, Chpt. 8 (Time of Day and Performance), London, Academic Press Ltd. Folkard,S. and Monk, T.H. (1985) Circadian Rhythms in Human Memory: in Hours of Work: Temporal Factors in Work Scheduling, edited by Folkard, S. and Monk, T.H., Chichester, Wiley. Tests: Psychological, physical.

A2. HUMAN CHARACTERISTICS

A2.35	*What system of recognition exists to reward good performance.* Most individuals are motivated by some recognition or reward for good performance. Failure to recognise or reward good performance can result in demotivation, distraction and a deterioration of performance.
A2.36	*What contingencies exist to assist a role holder who has domestic problems.* Most individuals are not able to leave behind their personal life when in the working environment. Life stress is associated with the life events and changes that are considered to be an unavoidable part of life. The death of a relative, financial worries, divorce, marriage, poor relationships with a partner or other members of the family, Christmas etc. can all distract, which can impair performance and increase the potential for human failure. In addition, such life events and changes can affect the health of an individual, which can also impair performance and increase the potential for human failure. It has also been found that effects of these life events and changes tend to be cumulative to the extent that ill health can result because a number of otherwise manageable events and changes have occurred at the same time. Where a individual fulfils a safety critical role, then the effect of life stress on his or her performance, confirmed or suspected, cannot be ignored. This particular potential cause of human failure requires skillful handling, and training will be required for most supervisors such that it is identified early and managed appropriately.
A2.37	*Are an individual's language and communication skills assessed with respect to the requirements to perform the role.* The ability to communicate such that the meaning is clearly understood by those who are intended to receive it is essential in most roles particularly those which involve safety critical tasks and the command of others in safety critical situations. Failure to successfully communicate can lead to incomplete understanding of the message and in the worst case the wrong message being received. The potential for human failure in communication (in terms of misunderstanding) can be increased where the people involved are of different nationalities, different ethnic backgrounds and different dialects. In addition many working groups tend to have their own jargon which may not be fully understood by all group members (some jargon may even have different meanings to different people). Jargon must also, therefore, be used with great care when giving safety critical instructions. In periods of high stress and workload, for example in an emergency situation, there will be an almost total reliance on verbal communication. It must be precise and send a clear unambiguous message which is understood by all concerned. Not all personnel have the skill required to do this and where individuals do not possess this skill, human failure to communicate can occur.

A2.37 Contd.	Communications skills, both verbal and written, therefore need to be assessed. Where no assessment is undertaken the potential for human failure will not be recognised, addressed and minimised. Tests: Psychological.
A2.38	*Does a sub culture exist associated with the role. Are there any superstitions associated with the role* In many work areas there exist sub cultures. These are usually found in areas where the members of a group have a common purpose which is substantively different to others at the work site. In the offshore environment, for example, there are many of these sub cultures. Most are easily identifiable, for example drillers, caterers and operations teams. A number of these sub cultures may have superstitions associated with them. These sub cultures and superstitions can dictate behaviour and this capability to increase the potential for human failure when such behaviour is inappropriate cannot be ignored.
A2.39	*Define the type and extent of distractions and interruptions, e.g. irrelevant speech, ad hoc phone calls, visitors to platform, that might be expected within the role from other people.* In most roles there exists the possibility of distractions and interruptions from other people. Such disruptions and interruptions can include those which arise from irrelevant speech, ad hoc phone calls requesting information, tannoy messages, and visitors. Although ways to minimise such distractions and interruptions should be investigated and put in place, there may be little control over a number of them and the ability to cope with those which cannot be avoided is extremely important for those who hold safety critical roles or who may assume such a role in an emergency situation. The management of unavoidable distractions and interruptions by persons who fulfil such roles is, therefore, of great importance and the ability to cope with them in all circumstances needs to be assessed. Inability to perform in the presence of such distractions and interruptions can lead to human failure. Tests: Psychological, physical.
A2.40	*Is the potential performance impairment from social psychological factors recognised and addressed within the working environment. Such factors include isolation from home and relatives; the relationships between the role holder and his or her peers, supervisor and sub-ordinates; group membership; prejudice; culture and society norms of behaviour; group norms of behaviour; group pressure and conformity; coercion; and social conditioning.*

A2.40 Contd.	Stress in the working environment can result from a number of social factors, and a failure to manage these adequately by an individual or supervision. Such stress can impair performance and increase the potential for human failure. Poor relationships with peers, supervisors and sub-ordinates, conflict, abuse of power are obvious sources of stress which can contribute to human failure (particularly in terms of human error). Annual appraisals, the actual methods of promotion and career development etc. are an additional source of stress to an individual particularly where these are perceived as unfair and biased by the individual. Group membership can be another stress generating social factor in the working environment. Social psychological research suggests that there exists a psychological satisfaction associated with membership of groups. The groups to which an individual feels psychologically a part (which can exist in or out of the working environment) are said to form his or her 'ingroups'. There is also some evidence to suggest that the psychological satisfaction to be gained by group membership is enhanced by the existence of an outgroup, that is, a group which an individual does not feel part and from which he or she wishes to dissociate. Such an outgroup can be real or imaginary. Members of an outgroup can experience discrimination and even hostility by members of a given ingroup. Examples of an individual's ingroups might be those associated with a particular race, nationality, language, religion. Quite arbitrarily defined ingroups can also form in the working environment particularly wherever people have the opportunity to interact and become interdependent. Research indicates that a common goal can unite ingroup members, and that competition can exacerbate discrimination and hostility towards an outgroup. The need for such self categorisations are not fully understood, however the existence of ingroups and outgroups creates a source of stress and alienation to individuals who are not part of the main groups that might exist within the working environment. This in turn can lead to distraction and so to human failure. Where an individual is a member of an ingroup, such membership might also contribute to human failure where it affects an individual's behaviour particularly as a result of fear of rejection by other members. Other social factors which can affects an individual's behaviour and so contribute to human failure include: culture and society norms, group norms, group pressure and pressure to conform, coercion, and social conditioning. The negative effects of many of the social factors are difficult to eradicate, however, their capability to increase the potential for human failure cannot be ignored.

A2.41	*How is the Company organised to support the role holder.* Many roles will require varying degrees of support from a Company's wider organisation. In some cases this support will be considerable and can include support in the following areas: technical, engineering, materials, personnel, logistics and emergency response. The effectiveness of this support will have an effect on the performance of the role holder particularly if it does not meet his or her requirements or expectations. Where there is inadequate or inappropriate support, then the potential for human failure exists. Organisations rarely stand still and the management of change is another aspect which can affect an individual's performance. Where the change is perceived as detrimental to the interests of individual or work team of which he or she is part, then moral can be affected and the potential for human error increased. The management of change therefore requires careful consideration with its full impact being considered before it is implemented.
A2.42	*Do external pressures (Company, supervisors, peer group) to meet deadlines and perform exist.* Role performance can be affected by the dictation of the order and timing of the tasks by external forces. Deadlines will motivate to a point (underload can lead to a deterioration of job performance), however unrealistic deadlines and too many tasks requiring attention at the same time will result in overload and a deterioration of job performance together with an increase in the potential for human failure. The potential for human failure can also be increased where tasks are rushed in order to meet tight deadlines. This is a particular problem if the pressure is applied locally, e.g. by immediate supervision.
A2.43	*Does the role holder undergo annual appraisal and ranking against others.* Whilst there are benefits associated with annual appraisal and ranking exercises, they can also have a demotivating effect on individuals where the appraisal or ranking does not meet the individual's expectations. Both can also affect the role holder's behaviour through the year where the individual believes that such behaviour could have a negative effect on his or her forthcoming appraisal or ranking, e.g. not admitting mistakes. Demotivation and inappropriate behaviour can both impair performance and increase the potential for human failure. They need, therefore, to be addressed if such exercises are performed on individuals.
A2.44	*Where the role involves working as part of a team, what is the age and experience of other persons in a team.*

A2. HUMAN CHARACTERISTICS

A2.44 Contd.	As with personalities, inappropriate mixes of age and experience amongst individuals within a team can impair performance. As the optimum age and experience range will depend greatly on the tasks being performed, assessment is required to determine this optimum and should consider all the tasks a team will be required to perform.
A2.45	*What are the irritants associated with the role, e.g. excessive quantities of irrelevant paper, electronic messaging, travel delays, excessive standards and procedures, equipment failure, repetitive false alarms and incorrect data, lack of private space.* Irritants can be a source of stress and as such increase the potential for human failure. The presence of such irritants should be addressed and, where possible, reduced or eliminated.

ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

B2 HUMAN REQUIREMENTS

The human requirements are defined as the requirements to perform the role.

B2.1	*What is the role title.* See B2.3.
B2.2	*What is required from the role according to the job description.* See B2.3.
B2.3	*What is required from the role according to those who perform the role.* The job description might identify the tasks and responsibilities that were envisaged to constitute the role, however this may not necessarily reflect reality in that the job description may under or over estimate the tasks and responsibilities. The tasks and responsibilities detailed in this Role Evaluation Tool should be those which reflect reality to the role holders. The role holder(s) should therefore identify the total number of actual tasks and responsibilities that constitute the role. Since role holders will become labelled by their role title which can affect their interaction with others, it should be determined whether the role title reflects the actual tasks performed within the role and the responsibilities.
B2.4	*What is the total number of tasks within the role according to those who perform the role . Provide a one line description for each task.* *Will any of the tasks result in conflicting responsibilities.* A one line description for each task should be given. Any potential conflicts in responsibility (for example, to achieve targets) should be identified. Where such exist, the possible effect on performance should be addressed.
B2.5	*Which of the tasks are perceived to be stimulating by the individual who performs the role.* The role holder(s) should identify those tasks which they consider to be stimulating and those which they consider to be boring. This will be a subjective account given by each role holder. A high proportion of boring tasks which occupy a number of hours can affect the role holders' performance in all tasks.

B2 HUMAN REQUIREMENTS

B2.6	*Which of the tasks are perceived as monotonous by the individual who performs the role.* See B2.5
B2.7	*Identify each task which has been termed a safety critical task (from task analysis if available).* From the total number of tasks identified above, those tasks which have been classified as safety critical (i.e. tasks which if not performed successfully could result in serious injury, fatality, loss of containment, or major damage to an installation or the environment), should be highlighted since it is these tasks which are likely to have the most significant consequences where there is human failure. These, therefore, will be the subject of later questions. Any classification of what constitutes a safety critical task should be broad enough to include those which may not be immediately apparent as being safety critical. Furthermore, where there is the possibility for non safety critical tasks to distract attention and impair performance, then these should be considered safety critical as well.
B2.8	*Under what circumstances are the safety critical tasks performed, i.e. normal conditions, abnormal conditions or emergency conditions.* The task performance of an individual will be affected by the conditions under which the task is performed. Boredom and overpractice can result in human failure when a task is performed under normal conditions. Unfamiliarity and fear can result in human failure when a task is performed under infrequent abnormal or emergency conditions.
B2.9	*Which of the safety critical tasks can be planned, and which will be unplanned.* Tasks which cannot be planned can result in human failure where there is insufficient time to plan, to provide the correct tools and information etc.
B2.10	*What factors decide the timing to perform a safety critical task and the task deadlines.* The factors which decide the timing and deadlines of tasks should be considered in terms of whether or not they are negotiable or whether they are realistic. A timing or deadline which is not negotiable or realistic can increase the potential for human failure.

B2. HUMAN REQUIREMENTS

B2.11	*Are the safety critical tasks supervised and to what degree.* Supervision provides a means of support to role holder in the execution of tasks both in terms of assistance during periods of high activity and in monitoring the appropriateness of critical decisions taken. This quality control ensures that the role holders decision making processes where flawed can be questioned and corrective action taken before they are implemented. Pro-active competent supervision of this type enhances both the role holder's performance and experience.
B2.12	*What are the requirements for situational awareness (risk perception) for each of the safety critical tasks performed within the role.* An individual's perception of risk in an event or situation will depend on the mental model that individual has formulated in response to it. This in turn will be influenced by the individual's knowledge, experiences, expectations, motivation, information available and the amount of attention an individual is able to give to the information available. The fact that a person's perception is influenced by his or her experiences and expectations means that his or her perception is limited essentially to what he or she can conceive. Therefore risk perception can be poor if the event is outside the realm of experience of an individual. This is further exacerbated by the fact that having developed a mental model of a situation, a person will tend to seek information which will support and confirm their model and ignore further sources of information or reject that which does not support their model.
B2.13	*Do any of the safety critical tasks within a role necessitate command, control or supervision of others.* Where command, control and supervision involves interaction with other team members, situations can arise where stress loading, multi-task management and information overload on supervision can result in decreased or flawed performance. It is important that supervision are aware of the dangers which can result from this, understand the initial signs of stress and data overload and know how to successfully manage these situations. For most supervision this will require training under stressful conditions. Recent experience in this field has shown that the majority of supervision require training of this nature and that following it the awareness of their capabilities is enhanced. The training itself needs to be carefully controlled so that the subject's stress levels are constantly monitored to ensure realism without exposure to stress levels the " trainee " cannot handle. The training thus prepares the "trainee" for future exposure to stress by giving him/her experience of the physiological effects of stress so that these can be self-diagnosed in the future.

B2.13 Contd.	Training which fails to expose a " trainee " to these stress related aspects of supervision will be of little value and could result in an inferior quality of supervision being exposed later to situations they will fail to handle effectively. In addition to being a stress factor, the command or supervision or others can have a distracting effect particularly where such is not consistent with an individual's personality. Where the role holder is required to command and supervise, the distractive effect of such should be taken into account when addressing the requirement for attention and vigilance in safety critical tasks performed within the role. Psychometric tests can be used with training to help establish the ease with which an individual can command or supervise. Tests: Psychological, physiological.
B2.14 (a)	*What is the maximum duration of the safety critical tasks within the role.* Tasks which necessitate prolonged mental or physical effort can impair performance and increase the potential for human error where the individual does not take or is restricted from taking a rest break. There should be adequate competent personnel available at any one time, such that a role holder can be relieved to take a rest break. The timing and duration of such breaks will depend on the task being performed and the individual performing it. Testing will be required to establish timing and duration requirements. Tests: Psychological, physiological, physical.
B2.14 (b)	*Do any of the safety critical tasks require vigilance for sustained periods of time.* A number of roles involve tasks which require an individual to detect small but significant changes in an environment or the occurrence of unusual and critical events. Although infrequent, these changes and events can occur suddenly and without warning. Having detected such changes or events, the individual is then often required to react appropriately and rapidly in order to prevent a serious escalation of the initial change or event. According to Parasuraman (see further reading below), vigilance can be defined as an individual's 'state of readiness' to respond to these infrequent critical changes and events'.

B2.14 (b) Contd.	Research in the controlled environment of a laboratory indicates that most people find it difficult to remain vigilant for any significant length of time (i.e. time periods greater than one hour) and a deterioration in vigilance is observed. Where a task combines the need for almost continuous attention with a mental load on short term (working) memory, this deterioration in vigilance performance is believed to be due the inability of an individual to maintain the mental effort needed over a prolonged period of time. Other human factors can affect the vigilance performance of an individual. Studies have indicated, for example, that alcohol can impair vigilance, whilst low frequency vibration can increase vigilance. An individual's circadian rhythms can also affect vigilance. There is also evidence to suggest that there exists individual variations in vigilance performance and that introverts generally perform better than extroverts on vigilance tasks. However attempts to use psychological and physiological measurement to determine and select highly vigilant individuals for vigilant tasks has not as yet been wholly successful. Further reading: Parasuraman, R. Vigilance, Arousal and the Brain, in Gale, A., and Edwards, J.A.,1983, Physiological Correlates of Human Behaviour, Vol. II: Attention and Performance, London, Academic Press. Tests: Psychological, physiological.
B2.15	*Do any of the safety critical tasks allow an individual to take rest breaks during their execution. How long are the rest breaks and of what do they consist.* See B2.14.
B2.16	*Do any of the safety critical tasks require a toolbox talk.* Where tasks require a toolbox talk, persons who will perform the task should be given the opportunity to feedback their understanding from the talk, prior to task commencement, to ensure that they have correctly interpreted the intended message.

B2 HUMAN REQUIREMENTS

B2.17	*What safety critical tasks require the completion of documentation prior to their commencement (e.g. Permit to Work).* Documents include checklists, permits and records. Documents can help ensure that safety requirements are implemented, authorise work to proceed, and measure safety performance. Documents are one of the management controls that can be applied to safety critical tasks.
B2.18	*Does the role require knowledge of terminology, slang, etc.* Where the role requires interaction with others and a knowledge of unique slang or terminology, human failure may result in the form of misunderstanding where an individual has insufficient knowledge of such language.
B2.19	*Does the role require fluency in the working language in order to command persons in an emergency situation.* Individuals whose native tongue is not the working language at the worksite may fail to communicate adequately in a stressful situation.
B2.20 (a) B2.20 (b)	*Taking each safety critical task in turn, what information is required to perform the tasks within the role.* All information that is required to perform each of the tasks should be listed. *Taking each safety critical task in turn, what information is available to perform the tasks within the role.* The actual information that is available to perform the tasks within a role should be listed. This should be compared with the information required as given above under B2.20(a). Omissions should be resolved.
B2.20 (c)	*How is this information presented to the individual, e.g. verbally (directly or via telephone or radio), audibly via an alarm system, visually via gauges, computer monitor or status lights, written etc.*
B2.20 (d)	*Are gauges etc. selected for ease of readability by those who will be using them.*

B2. HUMAN REQUIREMENTS

B2.20 (e)	*Are any of the controls unusual in terms of operation.*
B2.20 (f)	*Is any of the information colour coded. If so, what do the colours (e.g. yellow (amber), red, green, blue, white, other) represent.*
B2.20 (g)	*Is all information presented visually within the individual's field of vision from the normal work position.*
B2.20 (h)	*What is the quality of the information, is it reliable. Do any of the information sources have error which has to be corrected by the individual.*
B2.20 (i)	*Is all necessary information readily accessible.*
B2.20 (j)	*Is there any information which must be inferred from available information.*
B2.20 (k)	*What controls the timing of when information is presented. Is this information then available continuously or only for a short period of time.* The information that is available to an individual to perform the tasks within a role will have a major effect on task performance. It is vital that the information available to the individual is sufficient to perform the tasks, reliable, is presented at the right time and for adequate duration. Information which has to be inferred from other available information should be avoided where possible. The form in which the information is presented is also important. For example, audible information is omni directional and so is available to the role holder irrespective of his or her line of sight; however it can distract thought and can be transient and so can be forgotten, also although auditory information will generally be quicker to process mentally than visual information it can result in a greater number of errors; visual information is available for repeated reference and is not inhibited by background noise, but it is directional and requires to be in the role holder's field of view. All instrumentation should be tested for ease of readability by those who will be required to read them.

B2.20 (k) Contd.	Operation of controls should be consistent with the role holder's expectations which exist as a result of his or her knowledge and experiences both in the workplace and in everyday life. Colour coding should also be consistent with the role holders' expectations. For example from everyday life, people expect red to mean stop; therefore a red indicator which means go is likely to be misread particularly during times of stress. Where there is uncertainty as to how information should be presented, its timing and duration etc, assessments should be performed to determine the optimum for the working population concerned, taking into account the maximum amount of information that an individual could be expected to process at any one time (see B2.21). Tests: Psychological.
B2.21	*What is the maximum amount of information an individual would be expected to process at any one time: under normal situations?; abnormal situations?; and emergency situations?* Too much information, too little time to process information and/or excessive processing requirements can result in mental overload and lead to human failure. The constraints on human memory (in particular short term (working) memory) are generally considered to result as a consequence of human information processing limitations. The determination of whether or not a role holder is able to manage a particular situation (e.g. emergency) or task without overload is best carried out by simulation. The results should be considered applicable only to the individual tested since some people will perform better than others. An important factor in an individual's performance is his or her experience at the tasks. A more experienced role holder will process more information automatically which reduces the load on working memory. A simulation to determine whether there exists the potential for overload should also simulate the noise, heat or cold conditions that will exist in the working environment, as these factors can affect the point at which mental overload is reached. Other factors which can affect the point of mental overload are those which can cause fatigue, illness and emotional problems. Tests: Psychological.

B2. HUMAN REQUIREMENTS

B2.22	*Does the role involve periods of underload which can be broken by the sudden requirement to respond to a high workload.* Mental underload can result in poor performance. If people have insufficient work to do and are under stimulated they can become bored and external information necessary to perform a task can be missed. The lack of workload can also affect an individual's ability to react quickly and correctly in an emergency. The determination of the existence of mental underload is, as with mental overload, best carried out by simulation.
B2.23 (a)	*What safety critical tasks require use of mentally held knowledge and/or a skill or number of skills and to what extent. How is such knowledge and/or these skills acquired, e.g. acquired elsewhere, acquired 'on the job' or by specific training with an assessment process to determine whether the knowledge has been acquired and not forgotten and the skill(s) have been acquired and maintained.* Consideration should be given to what knowledge and skills are required to perform the safety critical tasks, and how such knowledge and skills are acquired and maintained by an individual. Assessments should be performed to ensure that an individual has the required knowledge and/or skills irrespective of where such are supposed to have been obtained. Periodic re-assessments should also be performed to ensure that the knowledge and/or skills are maintained. This is particularly important where they are required infrequently.
B2.23 (b)	*Is information obtained from the investigation of incidents used in a training programme as part of knowledge and skill acquisition.* The investigation of real incidents provides a valuable source of information which can be used to help determine what knowledge and/or skills are required by the role holder(s). Utilisation of this information as part of a training programme assists in the acquisition of such knowledge and skills.
B2.23 (c)	*Where skills are tested and assessed, how is the test and assessment determined to be a valid predictor of performance in the 'on the job'.* Where a skill is tested and assessed as a measure of performance 'on the job', there requires to be a validation of the test and assessment which demonstrates the correlation between the test and assessment and real performance. This is especially important where the test and assessment are carried out under simulated conditions.

B2.23 (d)	*Where skills are assessed, how are the assessors selected and assessed.* The assessors who assess others must have demonstrated their competency in those skills being assessed.
B2.23 (e)	*Is the knowledge acquired during training tested in practical applications.* A training programme which imparts knowledge in a 'classroom' situation may not be utilised by the 'student' in the real world. He or she may fail to see its relevance in a number of practical applications particularly where the use is not obvious. Therefore a training programme should aim to relate, apply and test the use of any imparted knowledge to a number of practical applications.
B2.23 (f)	*Is there any monitoring of performance 'on the job' after training.* The knowledge and skills that a role holder actually has from previous training and experience and that which he or she is assumed to have for correct performance of a task may not be the same. It is therefore important to determine what knowledge and/or skills a role holder requires to perform a safety critical task and to test whether the role holder actually holds this information. Knowledge and/or skills that are required to perform the safety critical tasks within a role will necessitate not only suitable training but also an assessment and periodic reassessment process to determine whether the knowledge has been acquired and not forgotten, and that the skills have been acquired and maintained (see B2.23(a). To supplement the assessment and reassessment process, the monitoring of an individual on the job should also be performed particularly after any initial training. This not only provides a measure of the value of the training to an individual whilst in the working environment, but also helps early identification of any problem areas.
B2.24	*Are individuals trained in diagnostic, problem solving and decision making skills which will help them to cope with unfamiliar situations.* Individuals should be trained to develop diagnostic, problem solving and decision making skills. This training should be relevant to the safety critical tasks which they are required to perform.

B2.25	*Are infrequently used but important knowledge and skills given frequent refresher training.* An individual's held knowledge and skills will deteriorate with time if such are utilised infrequently, therefore it is important that the knowledge and skills required for infrequent but safety critical tasks are maintained by frequent refresher training. An assessment and reassessment process (see B2.23(a)) will assist determination of how frequent such refresher training should be and also ensure that the knowledge and skills are acquired by an individual.
B2.26	*Do any of the safety critical tasks involve the interpretation and mental manipulation of information or for information to be held for any length of time in the individual's memory between receipt and usage.* The interpretation of information has limitations as highlighted under B2.12, the mental manipulation of information introduces the further potential for human failure (in the form of error) particularly when the individual is unable to allocate sufficient mental attentional resources to such manipulation (e.g. under times of stress or distraction); new information that is required to be held in an individual's short term (working) memory for longer than 6 - 12 seconds (even that which does not exceed short term (working) memory capacity limitations can become distorted or lost (forgotten) unless sufficient attention can be given to rehearsal).
B2.27	*Does the role require periods of passive monitoring and/or observation in isolation which are greater than half an hour.* Monitoring and observation performance can deteriorate where such are carried out uninterrupted for periods longer than half and hour.
B2.28	*Do the safety critical tasks require sustained attention (concentration) for long periods of time (greater than one hour).* The ability to maintain sustained attention will deteriorate where such is carried out for periods longer than one hour.

B2. HUMAN REQUIREMENTS

B2.29	*For all safety critical tasks, to what extent is information transmitted verbally between individuals (including during a handover of information).* The verbal transmission of information is transient and can be forgotten. Misunderstandings can result particularly where the speaker makes incorrect assumptions about what the listener does and does not know. To limit misunderstanding, the listener should feedback his understanding of a conversation to the speaker.
B2.30	*Are there clear procedures for the handover of information and responsibility between different shifts and/or individuals with different responsibilities, e.g. operations and maintenance.* The potential for human failure is increased where the procedures for handing over information and responsibilities are unclear.
B2.31	*For each safety critical task, what procedures and checklists exist to perform each of the tasks in the role? Who wrote these documents and how is it ensured that users understand the text? Where misunderstanding or ambiguity is identified, how is this corrected?* Where the author(s) and reviewer(s) of the procedures and checklists are not those who perform the role, then the role holder(s) should at least have input to their creation and review. The documents should be tested on all potential users to ensure that they fully understand their use and content. All procedures and checklists should be kept to a minimum in size for ease of use under all foreseen circumstances, but at the same time contain sufficient information to prevent wasted time in searching for cross referenced material in other documents. Text size should reflect the fact that emergency procedures and checklists will be used at times of stress and may be read under poor lighting conditions by users who have less than perfect vision. Content should also reflect the fact that users might be under stress and already have a high workload. The use of negatives in the text, e.g. "not on" instead of 'off' should be avoided as these take longer to mentally process, also the 'not' could be missed or forgotten if the text is read or heard in hurried or degraded conditions. Instructions should be ordered to reflect the order of necessary actions.
B2.32	*Is the range of applicability of the procedures and checklists documented and identified to the users.* Any assumptions or limitations in the use of a procedure or checklist should be clearly identified in the document and identified to the user.

B2: HUMAN REQUIREMENTS

B2.33	*Are the conditions under which the procedures must be used clear and unambiguous to the users. How are such tested.* Procedures which are clear and unambiguous to the author(s) and reviewer(s) may not be so to the users. Users should have input to the creation and review of procedures and their use should be tested prior to implementation.
B2.34	*Is there a simple and unambiguous indexing method for users to choose the required procedures in all foreseen situations. How is such tested.* Any indexing method should be tested to ensure all possible users consider it simple and unambiguous.
B2.35	*Has the use of the provided procedures been tested 'on the job'.* All procedures need to be tested by the users 'on the job'. Where this is not possible, their use should be tested in simulated exercises.
B2.36	*Is there a system for revising procedures in the light of experience.* There should exist a system for revising procedures where any problems associated with a procedure or checklist can be highlighted and resolved.
B2.37	*Can emergency procedures be implemented whether or not the user knows what is wrong, i.e. are they symptom based rather than event based.* It is more often the case that a number of symptoms are known about a situation but not the actual situation event. Therefore, unless specific requirements dictate otherwise, emergency procedures should be based on likely symptoms rather than possible events.
B2.38	*What problems solving might the individual be required to perform in the execution of each of the safety critical tasks.* The type of problem solving required in a role should be taught and practised by the individual.

B2: HUMAN REQUIREMENTS

B2.39	*What decision making might the individual be required to perform in the execution of each of the safety critical tasks.* The type of decision making required in a role should be taught and practised by the individual.
B2.40	*What is the minimum time for making a decision within the safety critical tasks. How accurate do such decisions need to be.* The less time available to make a decision then the less accurate a decision will tend to be. This is known as the speed accuracy trade off. In the extreme, where the time to make a decision is negligible an individual will have insufficient time to take in and process information and he or she will be reduced to making fast guesses. Therefore in safety critical decisions where accuracy is essential, the aim must be to provide an environment where the role holder has the maximum amount of time to gather and process (accurate) information and make a decision. Tests: Psychological.
B2.41	*Do the safety critical tasks require decisions to be made alone or part of a team.* Due to the pooling of knowledge and skills, team decision making is generally considered to produce better quality decisions and solutions to problems than the majority of the individuals in the team might produce alone. However, research indicates that such a team decision will, at best, rarely be better than the decision made alone by the most able member of the team, and there is evidence to suggest that, at worst, a team decision will be more extreme (involve greater risk) that a decision made by an individual alone. Team members might be more likely to overlook important information than individuals alone or conform to the consensus opinion. The status of individual members within a team, the compatibility of members and interpersonal relationships can also affect the final decision. These factors need to be taken into account when safety critical tasks involve the team decisions and ways to minimise their impact established.

B2.42	*In teams, is the allocation of responsibility and authority clear, complete, non overlapping, known to and accepted by all individuals including the role holder(s).* A role holder's responsibilities and authority should be clearly documented and identified to the role holder and to those who will be affected by such responsibilities and authority.
B2.43	*Are any changes in these responsibilities during a non routine event or emergency clear and practised.* Where there is a change in responsibility or authority as a result of a non routine event or emergency, such should be clearly documented and identified to those affected by such change.
B2.44	*Does the role include repetitive safety critical tasks. If so, what is the work and its frequency, e.g. number of times per 12 hours, number of days per week, etc.* Tasks that are performed repetitively may improve skill level and require less attention, however it is the lack of attention to a task which can also result in human failure (as mental error) particularly where a condition exists which makes a particular situation unique and different from previous occurrences.
B2.45	*Do any of the tasks required to be performed under the role necessitate physical (manual) work? What is the extent and nature of it this work?* Performance on a physical task will depend on whether the task requires repetitive movement using the same muscle groups, and static or dynamic contraction of muscle. It will also depend on an individual's muscle mass and cross sectional area, posture, motivation, and physical dimensions. Deterioration in performance or human failure (musculoskeletal injury) can result if the task requires a high degree of repetitive movement of the same muscle groups over a long period of time, and/or the task requires the long periods of static muscle contraction or excessive rapid dynamic contraction. Human failure can also result if the physical task requires an individual to adopt a poor or unstable posture, for example, as a result insufficient work space or the individual having unsuitable physical dimensions; the individual is under motivated (or too motivated and attempts a physical task beyond his/her abilities); or if the individual has insufficient muscle mass and cross sectional area to perform the task.

B2.45 Contd

Insufficient or incorrect attention to the physical work requirements of a role, to the working environment in which a physical task is to be performed, or to the human requirements can therefore result in human failure. Selection and training of an individual are also important.

The lifting of awkward or heavy loads in restricted work spaces is an obvious example of a physical task where there is the potential for human failure. However the lighter physical tasks more associated with non manual handling tasks (such as interaction with computers and 'office type' work) can also result in a range of human injuries known collectively as work related upper limb disorders. These injuries are located in the wrist, hand, arm, upper shoulder and neck of an individual. Research indicates that factors such as the amount of force being used over a period of time, the posture in which the forces are being applied, and the number of times that this occurs over a given time period all influence the likelihood that an individual can develop such disorders. Whilst the design of the work and the working environment will have the most important impact on reducing these injuries, as with the heavier physical tasks, selection and training of an individual are also important.

Further reading: Health and Safety Executive, 1990, Work related upper limb disorders, A guide to prevention, HMSO, London.

Tests: Physiological, physical.

B2.46 (a)

For any manual work that is performed:

What type of work is involved, i.e. static or dynamic physical effort, and over what time period (endurance).

In general, the greater the effort, then the greater the potential for human failure.

Is any of the movement repetitive, e.g. number of times per day, number of days per week.

In general, the more repetitive the movement, the greater the potential for human failure.

What is the duration of any applied physical effort.

Does any movement involve excessive joint angles.

B2.46 (a) Contd.	Movement requiring excessive joint angles can increase the potential for human failure. *What is the duration of any applied physical effort.* *Does any movement involve excessive joint angles.* Movement requiring excessive joint angles can increase the potential for human failure. *Does the movement require rapid bursts of activity or activity at a steady rate over a longer period of time.* Rapid bursts of activity can increase the potential for human failure. *Are people assigned to the task(s) based on some measurement of physical capability. How is the measurement determined to be a valid measurement of an individual's capability.* Not all individuals will be suitable to perform a particular physical task or tasks, therefore some form of selection will be required to minimise the potential for human failure. Those selected should also be given adequate training.
B2.46 (b)	*For manual handling (lifting) tasks in particular:* Insufficient or incorrect attention to the manual handling of loads can result in injury to the handler. Such injury can result in human failure which can result in an uncontrolled dropped load leading to impact damage of the manual handler or others in the vicinity of the manual handling operation. Sprains and strains to the manual handler are the most common type of injury. The back is the most common site of injury, the next common being the fingers/thumbs and the arm. Sprain and strain injury can arise from the incorrect application of force by the handler and/or applying a force for a long period of time. Poor posture and excessive repetition of movement can also be important contributory factors to sprain and strain injury. Many manual handling injuries are as a result of bad manual handling practice over a period of time rather than being truly attributable to any single handling incident. Consequently the injury or human failure can occur whilst handling a load which is not particularly great or awkward as well as whilst handling a heavy or awkward load.

B2.46 (b) Contd.

In Great Britain, and in other parts of the world there exists legislation that aims to protect the health and safety of an individual involved in manual handling operations. In Great Britain the majority of employees are protected by legislation that is general; for example Section 72(1) of the Factories Act (1961) states that 'a person shall not be employed to lift, carry or move any load so heavy as to be likely to cause injury to him'. The Offices, Shops and Railways Premises Act (1963) contains a similar statement. Whilst the Health and Safety at Work Act (1974, Sections 2 and 7) outlines the general duties of employers and employees, and contains no specific reference to manual handling as a separate activity. The International Labour Conference (1967) adopted ILO Convention 127 and Recommendation 128 'concerning the maximum permissible weight to be carried by one worker' in regular manual transport of loads. However, many countries, including Great Britain, have not given formal approval to these recommendations, its use is therefore limited.

In 1981, the National Institute for Occupational Safety and Health (NIOSH) USA published a work practices guide for manual lifting, which suggests two limits; the action limit (AL), below which no regulations or guidelines are necessary; and the maximum permissible limit (MPL), intended as a maximum above which manual lifting should not occur. Above the MPL any load is hazardous, whilst below the AL, the risk of injury or overexertion is minimal. Between the AL and the MPL ergonomic control is required.

In Great Britain, The Health and Safety Executive Manual Handling Operations Regulations are now in force, effective from 1st January 1993. These Regulations aim to state the minimum requirements for employers to avoid hazardous manual handling operations in the workplace 'so far as is reasonably practicable; to make an assessment of any hazardous manual handling operation that cannot be avoided so far as is reasonably practicable, and where it is not reasonably practical, then to perform other improvements to the task, the load and the working environment to reduce the risk. In line with much of the existing legislation in Great Britain, the Health and Safety Executive Regulations do not state specific weight limits requirements for manual handling operations, but it is an authoritative document which gives the minimum health and safety requirement for the manual handling of loads where there is a risk particularly from back injury to workers in any workplace. The Regulations implement the European Directive 90/269/EEC on the manual handling of loads, supplement the general responsibilities placed upon employers and employees by the Health and Safety at Work Act 1974 and the broader requirements of the Management of Health and Safety at Work Regulations 1992, and replace a number of earlier, outdated legislation.

B2.46 (b) Contd.	In Great Britain, reference should therefore be made to the Health and Safety Executive Manual Handling Operations (1992) for the minimum ergonomic requirements for manual handling operations and in association with the answers given to the questions set under B2.46b. Since these Regulations state no specific requirements on weight limits, the NIOSH guidelines which includes weight limits can also be consulted. However, since these NIOSH guidelines do not form part of the United Kingdom legislation or guidance, they can only be consulted for general information when used in Great Britain in association with the answers given under B2.46b in the absence of any specific weight limits set by the any United Kingdom authoritative body for general use. Likewise, the International Labour Conference (1967) adopted ILO Convention 127 and Recommendation 128 are available for general information in association with the answers given under B2.46b. A further publication by the Health and Safety Executive entitled 'Manual Handling - Solutions You Can Handle (1994) provides information to help employers avoid manual handling or to reduce the risk of injury where their assessment shows there is a risk associated with a manual handling operation that cannot be avoided. *What is the frequency of the lifting task(s)* *What is the distance over which the load is carried.* *What is the time for which the load is supported by an individual.* The frequency of the lift, the distance over which the load is carried and the time for which the load is supported by an individual, if excessive, can increase the potential for human failure as a result of fatigue. *What is the weight of the load.* As weight increases the risk of human failure increases. Individuals should be aware of their own limitations and the weight of the load prior to any manual handling operation. *Is the lifting operation performed by one individual.* *What is the height at the start of the lift.* The height at the start of the lift will affect the initial posture.

B2.46 (b) Contd.

What is the height at the end of the lift.

The height at the end of the lift will affect the individual's final posture.

Is any training performed on how to lift. What does the training consist of and what lifting technique is taught.

The disadvantages and advantages of different taught lifting techniques and the basic requirements for any training programme on manual handling is given in the Health and Safety Executive (1985) Manual Handling and Lifting: An Information and Literature Review with special reference to the back,

Is the workspace to perform the lift restricted (restricting posture).

A restrictive workspace to lift a load will create the potential for human failure when such restriction causes the individual to adopt an unbalanced posture which will impart excessive forces on the individual's musculoskeletal system (increasing the potential for strain or sprain injury) and cause the individual to fall, lose control of and/or drop the load or impact with solid surfaces where the individual's field of view is restricted etc.

Does the load have handles and, if so, where are they located.

Handles will assist in the manual handling operation providing they are located in a position which assists the lifting posture. The handles will also allow the manual handler to adopt a power grip where the fingers are wrapped around the handles instead of more hazardous holds such as the lumbrical (pinch) grip which is approximately six times weaker.

What is the size and shape of the objects to be lifted.

Both affect the individual's ability to grasp and hold a load and their overall centre of gravity (balance).

What type of tools are used to assist manual handling operations.

Mechanical aids to assist manual handling may only transfer the risk of injury to other parts of the human body and not remove the potential for human failure.

B2.46 (b) Contd.	*Under what conditions is the manual handling performed, e.g. transport up and down stairs, on floors which might be slippery, exposed locations where gusting winds might be experienced, temperature and humidity.* Manual handling in hazardous conditions will increase the risk of human failure. Manual handling under conditions of high temperature and humidity and low air movement will increase the potential for human failure due to increased sweat production as loads will be difficult to hold. Further Reading: The Health and Safety Executive (1985) Manual Handling and Lifting: An Information and Literature Review with special reference to the back, JDG Troup and FC Edwards.
B2.47	*What tools are available to perform the tasks within the role (including handheld tools, computers, control devices, cranes etc.).* For each tool, their adequacy to assist the user in the task should be assessed. Where the tools include control devices, factors such as frequency of use, sequence of use, importance of control, simultaneous use, device similarity (see below), symbolism used, spatial logic with displays, and prevention of inadvertent operation need to be addressed when assessing the adequacy in terms of control device type and control panel layout. *Are any of the tools used similar but not identical in operation, e.g. computer consoles, control panels.* Tools which are similar but not identical in operation can increase the potential for human failure (as error) particularly where the user's actions have become automatic to one particular design. *Do any of the tools generate vibration of the user' limbs etc.* Hand-arm vibration (as opposed to whole body vibration which is highlighted under A1.3) is now considered to be an important factor in human failure as a result of injury and is associated in particular with the use of tools which generate vibration in the hands and arm of the user. Important factors to consider are the acceleration of body parts caused by the vibration, the frequency and amplitude, the exposure time, and whether the exposure time is continuous or intermittent with rest breaks. The main injury associated with hand held vibrating tools is known as vibration white finger triggered when touching cold objects or exposure to the cold.

B2.47 Contd.	Vibration white finger can impair sensory performance and lead to a loss of manual dexterity and finger co-ordination in the early stages of the injury. Further exposure to vibration can cause progression to more severe injury. Further reading: The injury is still to be fully understood, however the Health and Safety Executive have produced a document entitled Hand Arm Vibration (1994). *Are the tools periodically checked and maintained.* *What training is given in the use of the tools.* *Are any of the tools unusual in terms of operation or usage, e.g. handles turn clockwise for OFF and decrease or turn anti-clockwise for ON or increase.*
B2.48	*Do any of the tasks require the use of personal protective equipment. What personal protective equipment is required. Can this equipment restrict movement, field of vision or the individual's heat maintenance.* Personal protective equipment which is issued to an individual may restrict movement, field or vision or affect the individual's heat balance. These factors must be considered when determining the human requirements to perform a task.
B2.49	*What support organisation is required to perform the tasks within the role.* The support organisation required to perform a task, particularly safety critical tasks, should be identified and put in place to ensure that they are available when required (e.g. 24 hours a day, every day). See also A2.41.

APPENDIX - WORKED EXAMPLE

A1. ROLE CHARACTERISTICS

Work Role: Offshore Deck Crew & Heli-Deck Assistant (HDA)

(Answers to questions are in italics).

A1.1	Define the physical environment in which the role will be performed in terms of ambient temperature. What is the variation in this temperature. What are the extremes in terms of maximum and minimum temperature? *Working temperature range minus 5 to plus 20 degrees centigrade (excluding wind chill).*
A1.2	Define the physical environment in which the role will be performed in terms of ambient radiative heat temperature. What is the variation in this temperature? What are the extremes in terms of the maximum and minimum radiative heat temperature? *Heat radiation possible from platform flare when working on heli-deck. Maximum and minimum radiative heat transfer requires measurement. Maximum duration on heli-deck approximately one hour under normal circumstances.*
A1.3	Define the physical environment in which the role will be performed in terms of vibration. What is the variation in this vibration? What are the extremes in terms of the maximum and minimum vibration? *No severe vibration.*
A1.4	Define the physical environment in which the role will be performed in terms of surrounding ambient pressure. What is the variation in this pressure over short and long periods? What are the extremes in terms of the maximum and minimum ambient pressure? *Not applicable.*
A1.5	Define the physical environment in which the role will be performed in terms of noise level (continuous and intermittent), i.e. undesired sound. What is the variation is this noise level? What are the extremes in terms of the maximum and minimum noise level? What are the noise sources? *Noise level high during helicopters movements (ear defenders worn). Maximum noise levels require measurement.*

A1. ROLE CHARACTERISTICS

A1.6	Define the physical environment in which the role will be performed in terms of air pollutants that might be present (continuous or intermittent). What is the variation in air pollutants and their maximum and minimum concentration in the atmosphere? *Air pollutants mainly from helicopter exhaust gases on heli-deck and turbine exhaust gases.*
A1.7	Define the physical environment in which the role will be performed in terms of relative humidity. What is the variation in relative humidity? What are the extremes in terms of the maximum and minimum relative humidity? Is the relative humidity controllable, and, if so, what factors determine the set level? *Weather determines relative humidity.*
A1.8	Define the physical environment in which the role is to be performed in terms of air movement (speed and rate of change in an enclosed environment). What are the maximum and minimum values? *Air movement determined by weather (wind speed) and draught from helicopters. Both can be hazardous especially wind speed when gusting.*
A1.9 (a) A1.9 (b)	Is the ambient lighting natural and/or artificial? What is the ambient lighting level, does this vary throughout a 24 hour period according to a set pattern? Can the lighting level be varied manually? *Ambient lighting is natural during the day and artificial (floodlights) during the hours of darkness. Restricted work in poor lighting conditions, e.g. fog or snow.* What is the main colour scheme of the environment? *Sea and sky.*
A1.10	Will performing the role cause an adverse change to any of the above environmental factors? If so, how and to what extent? *Main factor to change is air movement as a result of helicopter movements.*

A1: ROLE CHARACTERISTICS

A1.11	Is the environment in which the role is performed stimulating or monotonous? *Monotonous during normal operations.*
A1.12	Is the role performed under extreme changes in environmental conditions? *Yes due to changes in weather (wind, rain, storms etc.) and helicopter movements.*
A1.13	Define the type and extent of distractions and interruptions that might be expected from the environment. *Main distractions are as a result of noise (e.g. process blowdown, drilling activities, PA announcements, container impact, crane engines). Other distractions include working in wet clothing, restricted hearing as a result of wearing ear defenders), platform general platform alarm.*
A1.14	Define the environment in terms of potential chemical hazards. *Handle and work with numerous chemicals including chemicals transported by air and sea, detergents, and aviation fuel.*
A1.15	Define the environment in terms of potential physical hazards. *Stairs, crane hooks, tripping hazards on heli-deck, helicopter rotor blades.*
A1.16	Define the environment in terms of potential biological hazards. *Not applicable.*
A1.17	What are the potential chemical hazards that are introduced as a result of performing the role? *Handling and working with production and drilling chemicals transported by air and sea, detergents used for cleaning decks, re-fuelling helicopters.*
A1.18	What are the potential physical hazards that are introduced as a result of performing the role? *Movement of cargo loads, crane lifting from supply vessels, helicopter rotor blades.*

A1 - ROLE CHARACTERISTICS

A1.19	What are the potential biological hazards that are introduced as a result of performing the role? *Not applicable.*
A1.20	Define the workstation/site in which the role is performed in terms dimensions and layout? Who or what determined the dimensions and layout? *Dimensions of worksite are variable (heli-deck, loading areas etc.), layout also variable (container shape and put-down location, aircraft type etc.).* If the workstation/site is designed for human activity, is there a design standard? *The worksite is not designed for human activity.* Can the workstation/site be adjusted to suit different individuals of different dimensions? *No.*
A1.21	Where is the workstation/site located, e.g. at height, over the side of the platform, within a confined, enclosed or congested space? *Worksite can be at height and/or in a confined or congested space.*
A1.22	Are other activities outwith those associated with the role carried out at the same workstation/site? *Yes, drilling and craning activities.*
A1.23	What is the duty pattern associated with the role (i.e. what is the minimum, average and maximum number of hours one person might be expected to be on duty in a 24 hour period and how many days would such a duty extend)? *Minimum number of hours is 12, maximum is 16 hours over a 14 day duty period. On call period is 24 hours a day over a 14 day period in response to emergencies.*

A1. ROLE CHARACTERISTICS

A1.24	Is the role performed by more than one person to give continuous attendance with respect to time? If so, define the resultant shift schedule associated with the role? The following terminology has been used in the questions given under A1.24:

shift	the time of day on a given day that a role holder is scheduled to be at the workstation/site,
off time	hours not normally required to be at the workstation/site,
schedule	sequence of consecutive shifts and off time,
permanent hours	schedule that does not require the role holder to work more than one shift (the time of day worked is constant),
rotating hours	schedule that requires the role holder to work more than one shift (the time of day worked changes),
basic sequence	minimum number of days of shift and off days until a sequence begins to repeat.

The work role is performed by three persons plus a supervisor..

What is the basic sequence of the shift schedule?

14 days of shift days and 14 off days.

What is the normal total number of hours within each shift?

12 hours.

What is the maximum total number of hours within each shift?

16 hours.

What are the times of each shift in the shift schedule?

0700 hrs to 1900 hours.

A1.24 Contd.	What is the normal number of consecutive shifts in a schedule? *14.* What is the maximum number of consecutive shifts in a schedule? *14 (unless adverse weather prevents crew change).* What is the minimum, average and maximum total number of hours on shift in any preceding week ? *0 hours, 84 hours and 112 hours (maximum).* Is the shift pattern irregular? *The shift pattern is regular.* Is there a changeover within the shift schedule, e.g. days to nights or vice versa. and how is it performed? *There is no changeover within the shift schedule.* What are the shift handover times and duration, and how is this performed? *A verbal shift handover occurs at crew change (at end of 14 days).* What is the maximum number of hours possible between consolidated sleep? *11 hours.* What is the minimum number of hours consolidated sleep? What determines the timing of such sleep? *7 hours providing no interruptions. The timing of the sleep is determined by shift hours.* What contingency exists to manage situations where there is no relief of a role holder either at the end of a shift or at the end of a shift schedule. *No contingency.*

A1. ROLE CHARACTERISTICS

A1.25	How many accommodation musters would be expected between the hours 0600 to 1800 hrs and 1800 to 0600 hrs during a production period on the platform? *Maximum of 1 to 2 between 0600-1800 hrs and 2 to 3 between 1800-0600 hrs.*
A1.26	How many accommodation musters would be expected between the hours 0600 to 1800 hrs and 1800 to 0600 hrs during a high activity period on the platform (such as an annual shutdown for maintenance)? *As in A1.25 but can be higher during process start ups.*
A1.27	Define the sleeping environment in terms of temperature, pressure, relative humidity, noise level (continuous and intermittent), distractions, and air movement. *Sleeping environment can be draughty, noisy with a high number of distractions. Actual measurements required for temperature and relative humidity.*
A1.28	Define how an individual is selected for the role in terms of personality attributes. Is account taken of whether the individual who performs the role is to work in isolation or as part of a team? *Personality attributes not considered in selection process.*
A1.29	How are the fitness requirements for the role determined? *Specific physical fitness for the role not assessed.* What are the fitness requirements for the role, e.g. muscle build, hearing ability, absence of colour blindness? *Not defined but important factors to measure are considered by the role holder to be muscle build, hearing ability, alertness, eyesight.* What screening exists to determine fitness to work (psychological and physical)? Is the screening performed once as part of the recruitment process or periodically whilst the role holder is in the position? Does such screening test for drugs and alcohol abuse? *Company medical performed prior to selection, thereafter every two years up to the age of 50 yrs and once every year after the age of 50 years. Screening for drugs and alcohol (at medical and where abuse is suspected).*

A1.29 Cont.	Is there control of common non prescribed and prescribed drugs? *Use of prescribed drugs should be reported to the offshore medic.* How are transient illnesses such as colds and influenza handled? *Symptoms handled by offshore medic.*
A1.30	When and what food (including caffeine and alcohol) is available to the role holder? *Food is available at regular meal times, caffeine is available (in coffee and tea) throughout. No alcohol is allowed at any time whilst offshore).*
A1.31	Is the age of the role holder taken into account with respect to psychological and physical abilities? *No.*
A1.32	What is the minimum and maximum time any individual is assigned to the role? *The role holder is permanently assigned to the role.*
A1.33	What cover is available should the role holder not be available to perform the role for a given time period? *There is no cover other than from the other two individuals in the team.* How is a person to cover selected and trained? *Not applicable (no cover).* What assessment and reassessment is made to ensure the cover is competent in knowledge, skills, fitness etc.? *Not applicable (no cover).*

A1. ROLE CHARACTERISTICS

A1.34	Is account taken of the time of day a role holder will or could be required to perform a particular task? *No.*
A1.35	What system of recognition exists to reward good performance? *None.*
A1.36	What contingencies exist to assist a role holder who has domestic problems? *Compassionate leave at discretion of OIM, access to a telephone.*
A1.37	Are an individual's language and communication skills assessed with respect to the requirements to perform the role? *No.*
A1.38	Does a sub culture exist associated with the role? Are there any superstitions associated with the role? *Yes. An individual may be superstitious.*
A1.39	Define the type and extent of distractions and interruptions, e.g. irrelevant speech, ad hoc phone calls, visitors to platform, that might be expected within the role from other people? *Main distractions and interruptions come from tannoy announcements.*
A1.40	Is the potential impairment from social psychological factors recognised and addressed within the working environment? Such factors include isolation from home and relatives; the relationships between the role holder and his or her peers; supervisor and sub-ordinates; group membership; culture and society norms; group norms of behaviour; group pressure and conformity; coercion; and conditioning. *Such factors are given minimum attention.*

A1 - ROLE CHARACTERISTICS

A1.41	How is the Company organised to support the role holder? *Onshore support exists for routine and emergency operations.*
A1.42	Do external pressures (Company, supervisors, peer group) to meet deadlines and perform exist? *Yes.*
A1.43	Does the role holder undergo annual appraisal and ranking against others? *No.*
A1.44	Where the role involves working as part of a team, what is the age and experience of other persons in the team? *Variable. Supervisor is generally the oldest most experienced member of the team.*
A1.45	What are the irritants associated with the role, e.g. excessive quantities of irrelevant paper, electronic messaging, travel delays, excessive standards and procedures, equipment failure, repetitive false alarms and incorrect data, lack of private space? *Travel delays, weather, restricted working space, handling materials in a hurry, dual role.*

ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

B1 ROLE REQUIREMENTS

The role requirements are defined as the requirements to perform the role.

B1.1	What is the role title? *Offshore Deck Crew and Heli-Deck Assistant.*
B1.2	What is required from the role according to the job description? *Assist with the preparation for embarkation and disembarkation of aircraft passengers, for the unloading and loading of passenger baggage, and for the receipt and despatch of freight, supplies and equipment to/from the platform by air and sea.* *Operate appropriate procedures for embarkation and disembarkation of aircraft passengers, for the unloading and loading of passenger baggage, and for the receipt and despatch of freight, supplies and equipment to/from the platform by air and sea.* *Complete the above activities.* *Assist with the preparation for re-fuelling helicopters, re-fuelling and shutdown of re-fuelling operations.* *Heli-Deck Firefighting Response and Emergency Response.*
B1.3	What is required from the role according to those who perform the role? *As above.*
B1.4	What is the total number of tasks within the role according to those who perform the role? Provide a one line description for each task. *As given in Job Description.* Will any of the tasks result in conflicting responsibilities? *No.*

B1. ROLE REQUIREMENTS

B1.5	Which of the tasks are perceived to be stimulating by the individual who performs the role? *No routine tasks are perceived to be stimulating..*
B1.6	Which of the tasks are perceived as monotonous by the individual who performs the role? *All routine tasks are perceived as monotonous.*
B1.7	Identify each task which has been termed a safety critical task (from task analysis if applicable). *Fire fighting, aircraft handling and lifting operations. Back up emergency response team.*
B1.8	Under what circumstances are the safety critical tasks performed, i.e. normal conditions, abnormal conditions or emergency conditions? *Tasks can be performed under all conditions.*
B1.9	Which of the safety critical tasks can be planned, and which will be unplanned? *Most tasks are planned.*
B1.10	What factors decide the timing to perform a safety critical task and the task deadlines? *Timing and deadlines are determined by aircraft and shipping movements.*
B1.11	Are the safety critical tasks supervised and to what degree? *Tasks are supervised by the HLO and Supervisor to a high degree.*
B1.12	What are the requirements for situational awareness (risk perception) for each of the safety critical tasks performed within the role? *High.*

B1. ROLE REQUIREMENTS

B1.13	Do any of the safety critical tasks within a role necessitate command or supervision of others? *Command and supervision of aircraft passengers, ships' deckcrew crane operator and drilling deck crew required.*
B1.14	What is the maximum duration of the safety critical tasks within the role? *Up to 2 hours.* Do any of the safety critical tasks require periods of vigilance? *Yes, particularly those associated with aircraft and shipping.*
B1.15	Do any of the safety critical tasks allow an individual to take rest breaks during their execution? How long are the rest breaks and of what do they consist? *No.*
B1.16	Do any of the safety critical tasks require a toolbox talk? *Toolbox talks not given.*
B1.17	What safety critical tasks require the completion of documentation prior to their commencement (e.g. Permit to Work)? *Most tasks associated with aircraft and shipping movements involve completion of documentation.*
B1.18	Does the role require knowledge of terminology, slang, etc.? *Yes.*
B1.19	Does the role require fluency in the working language in order to command persons in an emergency situation? *Yes.*

ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

B1: ROLE REQUIREMENTS

B1.20 (a)&(b)	Taking each safety critical task in turn, what information is required and what is available to perform the tasks within the role? *No identified deficiencies providing documentation complete.*
B1.20 (c)	How is this information presented to the individual, e.g. verbally (directly or via telephone or radio), audibly via an alarm system, visually via gauges, computer monitor or status lights, written etc.? *Most information is presented verbally via radio.*
B1.20 (d)	Are gauges etc. selected for ease of readability by those who will be using them? *No.*
B1.20 (e)	Are any of the controls unusual in terms of operation? *No. However tools used can be unfamiliar with limited/no instruction.*
B1.20 (f)	Is any of the information colour coded? If so, what do the colours (e.g. yellow (amber), red, green, blue, white, other) represent? *Yes, lifting equipment is colour coded following testing.*
B1.20 (g)	Is all information presented visually within the individual's field of vision from the normal work position? *No.*
B1.20 (h)	What is the quality of the information, is it reliable? Do any of the information sources have error which has to be corrected by the individual? *Verbal information can be in error.*
B1.20 (i)	Is all necessary information readily accessible? *No, for example information on manifests may be incomplete.*

B1: ROLE REQUIREMENTS

B1.20 (j)	Is there any information which is inferred from available information? *No.*
B1.20 (k)	What controls the timing of when information is presented? Is this information then available continuously or only for a short period of time? *External factors control the timing of when information is presented. Information (verbal) is available only for a short period of time.*
B1.21	What is the maximum amount of information an individual would be expected to process at any one time: under normal situations?; abnormal situations?; and emergency situations? *Amount of information can be high under all conditions.*
B1.22	Does the role involve periods of underload which can be broken by the sudden requirement to respond to a high workload? *Yes.*
B1.23 (a)	What safety critical tasks require use of mentally held knowledge and/or a skill or number of skills and to what extent? How is such knowledge and/or these skills acquired, e.g. acquired elsewhere, acquired 'on the job' or by specific training with an assessment process to determine whether the skill(s) have been acquired and maintained? *All tasks require the use of mentally held knowledge and skills. The knowledge and skills are acquired on the job with some offsite training.*
B1.23 (b)	Is information obtained from the investigation of incidents used in a training programme as part of knowledge and skill acquisition? *No.*

ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

B1. ROLE REQUIREMENTS

B1.23 (c)	Where skills are tested and assessed, how is the test and assessment determined to be a valid predictor of performance in the 'on the job'? *Main required skills are tested and assessed at HDA Course. No validation of course known.*
B1.23 (d)	Where skills are assessed, how are the assessors selected and assessed? *Main skills assessed are movement around heli-deck, handling passengers and loads, re-fuelling of aircraft, heli-deck firefighting. Not known how assessors are selected and assessed.*
B1.23 (e)	Is the knowledge acquired during training tested in practical applications? *Only for emergency response.*
B1.23 (f)	Is there any monitoring of performance 'on the job' after training? *Yes.*
B1.24	Are individuals trained in diagnostic, problem solving and decision making skills which will help them to cope with unfamiliar situations? *No.*
B1.25	Are infrequently used but important knowledge and skills given frequent refresher training? *No, not for deck crew. Emergency response and HDA refresher training is given once every two years.*
B1.26	Do any of the safety critical tasks involve the interpretation and mental manipulation of information or for information to be held for any length of time in the individual's memory between receipt and usage? *Yes.*

ROLE CHARACTERISTICS AND REQUIREMENTS VERSUS HUMAN CHARACTERISTICS AND REQUIREMENTS

B1: ROLE REQUIREMENTS

B1.27	Does the role require periods of passive monitoring and/or observation in isolation which are greater than half an hour? *No.*
B1.28	Do the safety critical tasks require sustained attention (concentration) for long periods of time (greater than one hour)? *Yes.*
B1.29	For all safety critical tasks, to what extent is information transmitted verbally between individuals (including during a handover of information)? *Most information is transmitted verbally.*
B1.30	Are there clear procedures for the handover of information and responsibility between different shifts and/or individuals with different responsibilities, e.g. operations and maintenance? *No.*

B1. ROLE REQUIREMENTS

B1.31	For each safety critical task, what procedures and checklists exist to perform each of the tasks in the role? Who wrote these documents and how is it ensured that users understand the text? Where misunderstanding or ambiguity is identified, how is this corrected? *A number of procedures exist (External and Company, e.g. Personnel Procedures, Procedures to Secure Safety of Installation, Emergency Procedures Manual, Lifting and Slinging Procedures, Firefighting Regulations and Procedures, Heli-Deck Checks, Helicopter Communications, Helicopter Landing and Unloading, Helicopter Loading, Dangerous Goods Handled by Sea and Air, Helicopter Re-fuelling, Deck Cleaning Procedures, Heli-Deck Equipment Preparation).* *Procedures generally written by others with no checking for understanding by the user.*
B1.32	Is the range of applicability of the procedures and checklists documented and identified to the users? *Not always, generally left to supervisor.*
B1.33	Are the conditions under which the procedures must be used clear and unambiguous to the users? How are such tested? *Not tested.*
B1.34	Is there a simple and unambiguous indexing method for users to choose the required procedures in all foreseen situations? How is such tested? *Procedures can have indexes but not tested for simplicity and ambiguity.*
B1.35	Has the use of the provided procedures been tested 'on the job'? *No.*

B1 ROLE REQUIREMENTS

B1.36	Is there a system for revising procedures in the light of experience? *Incident Reporting System.*
B1.37	Can emergency procedures be implemented whether or not the user knows what is wrong, i.e. are they symptom based rather than event based? *Most procedures are event based.*
B1.38	What problems solving might the individual be required to perform in the execution of each of the safety critical tasks? *Most problem solving would be performed by supervisor.*
B1.39	What decision making might the individual be required to perform in the execution of each of the safety critical tasks? *Decision making is in terms of own safety and safety of others.*
B1.40	What is the minimum time for making a decision within the safety critical tasks? *Seconds.* How accurate do such decisions need to be? *Decisions need to be accurate.*
B1.41	Do the safety critical tasks require decisions to be made alone or part of a team? *Variable.*
B1.42	In teams, is the allocation of responsibility and authority clear, complete, non overlapping, known to and accepted by all individuals including the role holder(s)? *Yes.*

B1. ROLE REQUIREMENTS

B1.43	Are any changes in these responsibilities during a non routine event or emergency clear and practised? *Not always.*
B1.44	Does the role include repetitive safety critical tasks? If so, what is the work and its frequency, e.g. number of times per 12 hours, number of days per week, etc.? *Yes, three to four times per day (handling aircraft passengers and baggage etc.)*
B1.45	Do any of the tasks required to be performed under the role necessitate physical (manual) work? What is the extent and nature of it this work? *Yes, deck cleaning, lifting operations and emergency response.*
B1.46 (a)	For any manual work that is performed: What type of work is involved, i.e. static or dynamic physical effort, and over what time period (endurance)? *Most manual work is dynamic for periods up to 30 minutes where a task can be repeated every 30 seconds up to 36 times..* Is any of the movement repetitive, e.g. number of times per day, number of days per week? *Yes, unloading and loading aircraft baggage, approximately 36 times per aircraft.* What is the duration of any applied physical effort? *Up to 30 minutes.*
	Does any movement involve excessive joint angles? *Yes.*

B1. ROLE REQUIREMENTS

B1.46 (a) Contd.	Does the movement require rapid bursts of activity or activity at a steady rate over a longer period of time? *Tasks can involve both types of activity.*
	Are people assigned to the task(s) based on some measurement of physical capability? How is the measurement determined to be a valid measurement of an individual's capability? *No.*
B1.46 (b)	For manual handling (lifting) tasks in particular: What is the frequency of the lifting task(s)? *Variable.* What is the distance over which the load is carried? *Up to 30 feet.* What is the time for which the load is supported by an individual? *Approximately 30 seconds.* What is the weight of the load? *25 lb to 56 lb.* Is the lifting operation performed by one individual? *Yes.* What is the height at the start of the lift? *0 to 3 feet.*

B1 ROLE REQUIREMENTS

B1.46 (b) Cont.	What is the height at the end of the lift? *0 to 3 feet.* Is any training performed on how to lift? What does the training consist of and what lifting technique is taught? *No.* Is the workspace to perform the lift restricted (restricting posture)? *Yes.*
B1.46 (b) cont.	Does the load have handles and, if so, where are they located? *Not all loads have handles.* What is the size and shape of the object to be lifted? *Variable.* Under what conditions is the manual handling performed, e.g. transport up and down stairs, on floors which might be slippery, exposed locations where gusting winds might be experienced? *Manual handling is performed under all conditions stated above.*
B1.47	What tools are available to perform the tasks within the role (including handheld tools, computers, cranes etc.)? *Mechanical lifting equipment is available for lifting heavy loads. High pressure cleaning equipment.* Are any of the tools used similar but not identical in operation, e.g. computer consoles, control panels? *No.*

B1 ROLE REQUIREMENTS

B1.47 Contd.	Do any of the tools generate vibration of the user' limbs etc.? *No.* Are the tools periodically checked and maintained? *Yes.* What training is given in the use of the tools? *Minimum training given.* Are any of the tools unusual in terms of operation or usage, e.g. handles turn clockwise for OFF and decrease or turn anti-clockwise for ON or increase? *No.*
B1.48	Do any of the tasks require the use of personal protective equipment? What personal protective equipment is required? Can this equipment restrict movement, field of vision or the individual's heat maintenance? *Most tasks require the use of personal protective equipment (safety boots, coveralls, visors, ear defenders. safety glasses, gloves, slick suits, waterproof clothing, fireman suits).* *Equipment can restrict movement, restrict field of vision (glasses) and handling ability (gloves).*
B1.49	What support organisation is required to perform the tasks within the role? *Onshore support for management of passengers and freight.*

APPENDIX - WORKED EXAMPLE

SUMMARY OF ASSESSMENT OF RESPONSES (COMPARISON WITH SECTIONS A2 AND B2)

The above represents an initial investigation into the role of Offshore Deck Crew and Heli-Deck Assistent to provide a worked example on how to utilise the RET. Actual use of the RET would aim to provide more detailed responses to the questions given in Sections A1 and B1.

Comparison of the responses (in italics) with Sections A2 and B2 of the RET indicates that the effects of the physical environment on performance require further investigation. Such an investigation should include determination of the effects of temperature, heat radiation, air movement, physical hazards, distractions and interruptions on performance.

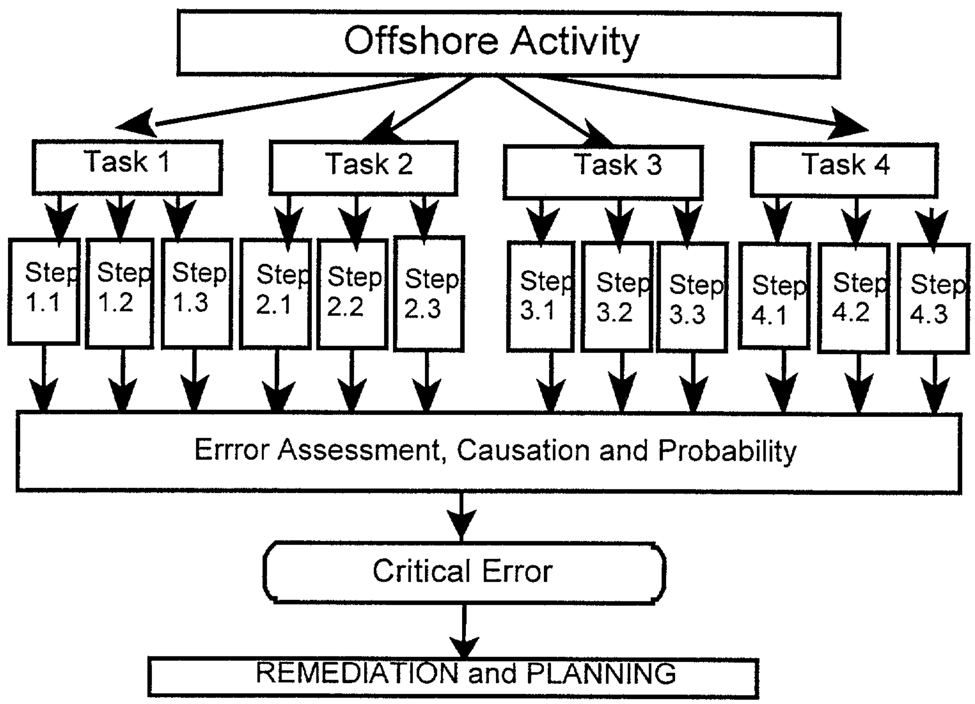
Whilst the majority of other responses highlight at least some inconsistency with the information and guidance given in Sections A2 and B2 which require further investigation, other main areas of investigation are considered to be the handling of chemical freight, effect of shift work, the selection process of individuals for the work role, training and assessment requirements, communication, the testing of procedures for understanding and ease of use by the role holder, the manual handling of loads in the physical environment experienced by the role holder, and the selection of personal protective equipment to minimise movement and field of vision etc. restrictions.

The responses are consistent with an assessment of the main type of accidents that occur in the working environment for Deck Crew and Heli-Deck Assistants. These accidents include injuries from the performance of manual work in a restricted space, insecure loads in containers, incomplete labelling on freight (e.g. incomplete weight labelling), blind lifting and spillages.

APPENDIX E

PRELIMINARY HUMAN ERROR ASSESSMENT TOOL

Purpose Identify critical errors, and remedial measures. Improve contingency plans.	The Human Error Potential Assessment, or HEPA, is a tool designed to allow teams of trained users to examine the activities of a particular **system** in order to identify those potential human errors that could lead to significant failure of the system. The purpose of the HEPA is to identify **critical errors**, to recommend measures to reduce the likelihood of their occurrence, and to foster plans for dealing with the consequences of the errors should they occur. Since the tool requires a thorough examination of system activities by a trained assessment team, the process itself may lead to many other suggestions for improvement.
Scope	Although the HEPA tool can be applied to any system, it was developed to evaluate the potential for human error during offshore and remote onshore oil and gas drilling and production activities.
Limitations Will not eliminate all errors. Subjective.	The HEPA tool cannot identify every possible error nor can it solve all problems related to humans in systems operations. It is a subjective and qualitative process. Its strength lies in the diligence and insight of those involved in its application. It should never be rigidly applied and should be modified as necessary. If the process is undertaken conscientiously and remedial measures are applied, it can reduce the risk associated with the activities examined.
General Approach Define, Identify, Remediate, Plan.	In general, the approach involves defining an activity in its most elementary steps so that potential errors associated with each step can be identified. The errors identified must be rated in terms of the likelihood of their occurrence and the severity of the consequences. Errors that have high rating, or critical errors, must be further analyzed for their potential causative factors so that remedial measures can be recommended. Contingency plans must also be examined to assess how the occurrence of critical errors will be managed.
	The application of the HEPA tool involves following the steps necessary to answer the following questions:
Gross Task Analysis	1. What is the activity of interest? 2. What are the major tasks performed in the activity? 3. What are the steps performed in each major task?

Error & Accident Analysis, Critical Incident Interviews.	4. What are the potential errors for each step? 5. How likely is each error? 6. What is the consequence of each error? 7. Which are the most critical errors? 8. What is the cause(s) of these errors?
Remediation & Contingency Analysis.	9. How can these errors be reduced or remediated? 10. Are the plans for dealing with critical error occurrence adequate?
	An overview of the General Approach of the HEPA is presented in the diagram given below: 

Phase 1	Gross Task Analysis
Gross Task Analysis (GTA)	The first step in reducing critical human errors is to analyze the operations in which they can occur. This involves performing a Gross Task Analysis. It is considered gross in the sense that is not to be performed for the purpose or at the level of detail that such analyses generally are performed.
Objectives	This analysis is a process of defining the boundaries of the activity of interest, then reducing the activity to its most elemental steps. The objectives of this analysis are to define the activity of interest, define the tasks required to perform the activity and to identify the steps necessary to perform each task. It must be stated that this is an arbitrary and subjective process. Boundaries can be drawn in many ways and steps can be defined at various levels. However, the ultimate goal is identifying potential errors associated with each step, so it is important that the boundaries be narrow and that the steps be as elementary as possible.
Requirements	• An evaluation team of three or more people, at least one of whom is knowledgeable about the activity being analyzed. • Job or task descriptive information. • Copies of Forms 1 and 2.
Procedures	The following procedure outlines the analytic process. Guidelines and examples are presented for clarity. GTA 1: Define Activity An activity is a distinct subset of the overall operation. It is goal directed and has action oriented tasks and steps within each task. Examples of activities: Surface vessel supply Crane operations Well-kick control Record and describe the activity of interest on Form 1.

Procedures (Cont.)	GTA 2: Define Tasks A task is defined as a **function** performed by either a human or a machine in the accomplishment of an activity. Examples of tasks in crane operation: ■ Position crane to predetermined location ■ Attach load ■ Lift load ■ Move load ■ Position load to predetermined location ■ Release load ■ Secure crane Record and describe tasks on Form 1. Transfer each task to a single Form 2. GTA 3: Define Steps Steps are the actions involved in completing a task. A step is a subgoal required to achieve task completion. Examples of steps in positioning crane to predetermined location: a. Select location to move crane b. Visually acquire location c. Operate crane controls to move/position/lower crane d. Stop crane Record and describe the steps associated with a given task on its corresponding Form 2.

Phase 2	Error Analysis
Error Analysis (EA) Objective	The ultimate objective of the Error Analysis is to identify those critical human errors that might occur during the activity of interest. This process involves analyzing the steps, reviewing accident data and interviewing knowledgeable personnel.
Requirements	• The evaluation team. • Five personnel experienced in the activity that will be interviewed in the critical incident process (see CI). • Any available accident data for this activity or its onshore equivalent. • All Form 2s from the GTA.
Procedures	EA 1: Identify Potential Human Errors The critical human errors are derived by first examining the steps associated with each task and then identifying potential human errors for each step. Equipment or material failures are not part of the scope. Descriptive terms used for these potential errors are generally negative in content (i.e., state that the step is performed incorrectly or omitted). An example of a human error in positioning the crane: Choosing incorrect location to which to move the crane Incorrectly operate crane controls Record and describe the potential errors on Form 2. EA 2: Rate Likelihood of Errors The second step in the EA is to assess the likelihood of occurrence for each potential error. This is done using the five point rating scale given below: Likelihood of Error 1 Low — 2 — 3 Medium — 4 — 5 High For example, incorrectly operating crane controls may receive a "2" rating for likelihood of occurrence. Record the average ratings of team members in column 3 on Form 2.

Procedures (Cont.)	EA 3: Rate Consequences of Errors Each error must be rated in terms of its consequences. Again this is a subjective estimate by each team member, with the average being recorded on the form. The rating scale is presented below: Consequence of Error 1 Delays; 2 Equipment Damage; 3 Injuries and Major Equip. Damage; 4 Death, Severe Inj., Equip. Loss; 5 Loss of System and Lives Example: Incorrectly operating crane controls. Due to the severity of the error consequences this error could rate a high severity value of "4." Record average ratings of team members in column 4 on Form 2. EA 4. Estimate Risk Risk is defined as the likelihood of unwanted consequences. In this case, risk is estimated by the product of the subjective ratings. Example: Incorrectly operating crane controls. Since the likelihood of error was a "2" and the consequence of the error was a "4," multiplying the two ratings together gives an **"8"** for that human error. Multiply the ratings in columns 3 & 4 and enter in column 5 on Form 2. Remember the values in columns 3 and 4 are the *average* of the raters' scores.

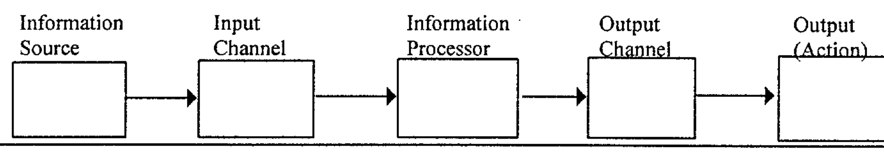
Phase 3	Accident Analysis
Accident Analysis (AA) Objective	Accident data are analyzed to supplement and reinforce the EA. All accident data available from both on and offshore systems related to the particular activity are reviewed. Errors related to task steps are identified and enumerated.
Requirements	• The evaluation team. • Written accident reports available for the activity. • Completed Form 2s from previous analyses.
Procedures	AA 1: No Accident Records If no accident data exist for a given step, the analysis is complete for that step. Continue the review until accident data is found for a given step. AA 2: Accident Data Present If accident data exists for a given step, examine it carefully to determine if there is an error present that has been previously listed for that step. If the error has been previously enumerated, revise the values in columns 3 and 4, as necessary, then proceed to the adjustment of the risk estimate (AA 4). If the error has not been enumerated, add it to the list under the step (or on a supplemental page). AA 3: Rating Likelihood and Consequences Since the accidents have occurred, they have a high likelihood and some level of consequence. Therefore entries in columns 3 and 4 should reflect the appropriate values. Estimate these values and enter them on the appropriate line in columns 3 and 4 on Form 2. Place the product of these two values in column 5.

Procedures (Cont.)	AA 4:	Adjustment of Risk Estimate The risk estimate in column 5 will be modified by known accident experience. The modifier will be one of three values: 1 for no accident experience 2 for few accidents 3 for frequent accidents Place one of these values in column 6 on Form 2. Example: During past accident record review, the team noted a few accidents involving the crane activity. Improper or incorrect operation of the crane controls was determined to be the cause of the accident. Therefore, a "2" is assigned in column 6 to correspond to the few accidents attributed to that occurrence.

Phase 4	Critical Incident Interviews
Critical Incident Interviews (CI)	The critical incident (CI) technique is a method of accident research in which people who have experience with the activity of interest are interviewed and asked to provide detailed descriptions of unsafe acts, near-misses or actual accidents they have observed. The basic assumption of the technique is that, given enough information regarding a large number of these incidents, one can determine the errors associated with an activity that lead or might lead to an accident or near-accident.
Objectives	There are three objectives for the CI interviews; first, to refine or supplement the error and accident analyses; second, to gather information about the level of knowledge of the interviewees concerning the responses they should or would make in the event that the errors noted would have resulted in accidents; and, third, to observe the performance or simulated performance of the operation of interest.
Requirements	• The evaluation team. • At least five personnel that currently perform or supervise the activity of interest. • Completed Form 2s from the previous analyses. • Observation of the operation, if possible.
Procedures	Data can be obtained through several methods, including personal interviews, group interviews, questionnaires, checklists, and observation. The personal interview is the preferred method of obtaining data, although it is time consuming. CI 1: Conduct Interviews Interview each person individually. Make the interviews as informal as possible. Let those being interviewed know that no names will be included in the report and that all responses are strictly confidential. One of the evaluation team members can lead by asking the questions outlined in Form 3, the others will record responses and ask follow-up questions. Examples: The following types of questions can be asked to obtain data: "Think of a situation in which an accident occurred or almost occurred while performing a given task. What were the general circumstances leading up to this accident? Exactly what did the operator do which contributed to the incident? When did this incident occur? What was the operator's job? How long has the operator been performing this job? What would you do if this type

Procedures (Cont.)		of accident occurred?" The questions and responses must be of sufficient detail to provide information which will allow the investigators to make inferences and predictions about the associated behaviors. Record the responses on Form 3.
	CI 2:	Revise Error Data For each incident described in the interviews, determine if there is an error present that has been listed for a step on Form 2. If the error has been previously enumerated, revise the values in columns 3 and 4, as necessary, then proceed to the adjustment of the risk estimate (AA4). If the error has not been enumerated, add it to the list under the step (or on a supplemental page).
	CI 3:	Rating Likelihood and Consequences Since the near-misses, incidents or accidents have occurred, they have a high likelihood and some level of consequence. Therefore entries in columns 3 and 4 should reflect the appropriate values. Estimate these values and enter them on the appropriate line in columns 3 and 4 on Form 2. Place the product of these two values in column 5.
	CI 4:	Adjustment of Risk Estimate The risk estimate in column 5 will be modified by known incident experience. The modifier will be one of three values: 1 for no incident experience 2 for few incidents 3 for frequent incidents Place the appropriate value in column 7 on Form 2.
	CI 5:	Observe Operations (if possible) Look for potential error sources. Listen to proposed remedies for the errors. Example: With a knowledgeable working person, observe the operation of the crane controls and watch for inadvertent activation of another control. Perhaps the worker will suggest a guard over the troublesome control.

Phase 5	Determine Critical Errors
Determine Critical Errors (CE)	While all potential human errors are of interest and need to be addressed in some fashion, those that can cause significant loss should be addressed first. These potential errors are defined as critical. An error may be deemed critical if the estimate of the risk associated with them is above a specified level. The level specified may be arbitrarily determined, or the list of potential errors may simply be ranked in order with a cut-off imposed at natural break points in the list. However it is done, the selection of critical errors is necessary so that a manageable number of errors remain for further analysis.
Requirements	• The evaluation team. • All the previous completed Forms • Form 4.
Procedures	CE 1: Determine Modified Risk Value Multiply the estimate of risk in column 5 by the larger of the accident modifier in columns 6 or incident modifier in column 7. Example: The accident modifier value is a "1", while the incident modifier is determined to be a "2". Therefore, the value of "8" obtained by multiplying columns 3 and 4 values, is now 8*2 or "16", for the new modified risk value. Record the Modified Risk Value in Column 8. CE 2: Determine Critical Errors Select all potential errors that have a value above 12. Example: Given the value of "16" above, it must be determined to be a critical error. Record the task, step, error and risk information on Form 4.

Phase 6	Error Causation
Error Causation (EC)	This stage of the HEPA is directed at finding the causes of the potential human errors that were rated as critical. This is an analytic process that categorizes and classifies the selected errors by the factors that may induce or exacerbate them. Once these factors are known, remedial measures can be developed to reduce the likelihood of their concurrence. It must be understood that humans make many errors, many of which are not system related. Fortunately, most errors are harmless, self correcting or are tolerated well by the machine being operated. The non-system related, or idiosyncratic errors, are very difficult to remediate and are not the focus of this assessment. System related, or systemic errors, on the other hand, can be controlled. The approach taken to determine error causation is an information processing approach. This approach assumes that errors result from some failure in the information processing chain. This chain is depicted in the diagram below. 
Information Sources	Information sources include anything or any person in the operator's environment that has the potential to provide indications of the system's status. This includes parts of the machinery such as gauges, lights, and auditory signals; by-products of the machinery's operation such as changes in temperature, noises, and odors; and people such as signalers, other operators, etc.
Input Channels	Any environmental source of information must ultimately impact one or more of the operator's sensory modalities in order to be perceived. The most commonly used in control tasks are visual and auditory sensations, although other modalities such as touch and smell are often of critical importance in determining what actions are appropriate in a given situation.
Information Processor	The human central nervous system acts an information processor. It takes all the sensory data from the input channels to the central nervous system, generates thoughts, and selects or programs actions. Some information processing is simple or "reflexive" in nature, as when we touch a hot stove and immediately jerk our hand away. Even in such simple cases, the central nervous system has processed a sensory input (from a pain receptor in the skin) and sent the command for action (to motor neurons in the arm and hand). More complex actions, such as those requiring conscious decision-making on the part of the operator, involve the brain and mental functions such as memory (of learned rules or previous experience), comparisons (between current and expected conditions), attention (determining which inputs are important and which to ignore), and response generation (planning and sequencing actions).

Output Channel	Once an action plan is generated mentally, the appropriate signals must be sent in order to carry it out. The human body has several output channels making actions possible. All share the common features of motor neurons under central nervous system control transmitting signals to the skeletal muscles that make movement and speech possible.
Action	Actions are the controlled movements of the body's limbs or vocal apparatus to affect a change in the environment or the body's position relative to the environment. They can be purposeful or reflexive in nature, but all share the common features of central nervous system control and coordinated, sequenced movement of the body.
Failures in the Information Processing Chain	The failures that occur can be attributed to humans, acting as information sources, processors or receivers (signal person, machine operators, etc.) or actors; machines that serve as information sources, action elements or transmission channels (controls, displays, radios, etc.), or to the environment in which the communication takes place (noise, dark, adverse weather, etc.) Failures in the information processing chain can be caused by: Failure of the source where the needed information is: ■ not present ■ not present at the right time ■ not detectable ■ incorrect Failures in the input channel that cause the information to be: ■ disrupted ■ distorted ■ delayed Failures in processing such that the information is: ■ misinterpreted ■ ignored

Failures in the Information Processing Chain (Cont.)	Failure in the output channel such that the action is: ■ delayed ■ improperly controlled Failure in the output such that the action is: ■ incorrectly performed Each critical potential human error must be classified according to one or more of the sources of information processing failures. Once these are known, remedial measures can be identified.

Phase 7	Error Cause Assessment
Error Cause Assessment	In most interactions between humans and the systems they operate, the potential causes of errors are related in complex and often not immediately apparent ways. It is important to realize that there will be alternative explanations and multiple possible causes for any potential error. Without addressing all the likely causes of error, remedial measures taken will not be enough to eliminate the risk, and, in some cases, may even raise the risk of an error. In classifying human errors, therefore, it is crucial to consider all possible reasons for the error by judging the likelihood of any causal explanation. Form 5 is to be used in conducting an error cause assessment.
Objective	The objective of Error Causation is to identify and classify the important potential causes of each critical error so that remedial steps can be developed to address each error. Remember that the Causal assessment is to be carried out only for those errors rated as "critical" in the Error Analysis. These are the errors that, through a combination of their likelihood and their consequences, are the most important to address. Consulting the list of critical errors, the following procedure will be used to identify the potential causes for those errors.
Requirements	The evaluation team All the previously completed forms Form 5
Procedures	The following procedure outlines the analytic process. Guidelines and examples are presented for clarity. EC 1: Select Critical Errors for Analysis A critical error is one identified as high risk as a result of the preceding analyses (GTA, EA, AA, and CI). These are the errors that, by virtue of their likelihood and/or consequences, pose the greatest threat to safe and continued operation. Examples of critical errors: Failure to operate crane controls correctly Failure to see warning light for pressure level Record the critical error of interest on Form 5. Use one copy of form 5 for each critical error identified in Forms 1-4.

Procedures (Cont.)	EC 2: Describe Possible Causes of Error

The possible causes of error are based on the information processing approach. Errors can result from one or more failure(s) at one or more link(s) in the information processing chain:

- Information Source
- Input Channel
- Information Processor
- Output Channel
- Output (Action)

At each link in the information processing chain, use Form 5 to list the possible error causes of that type.

Examples of Potential Error Causes:

Information Source:

- Warning Light Burned Out
- Background Noise, Siren Inaudible

Input Channel:

- Operator Deaf
- Operator Color Blind

Information Processor:

- Operator Misreads Gauge
- Operator Confuses Similar Correction Procedure

Output Channel:

- Operator Applies Excessive Pressure to Controls

Output (Action):

- Operator Activates Controls Out of Intended Sequence
- Operator Turns Control Handle in Opposite Direction of that

Record the list of potential Error Causes on Form 5 for each link in the Information Processing Chain.

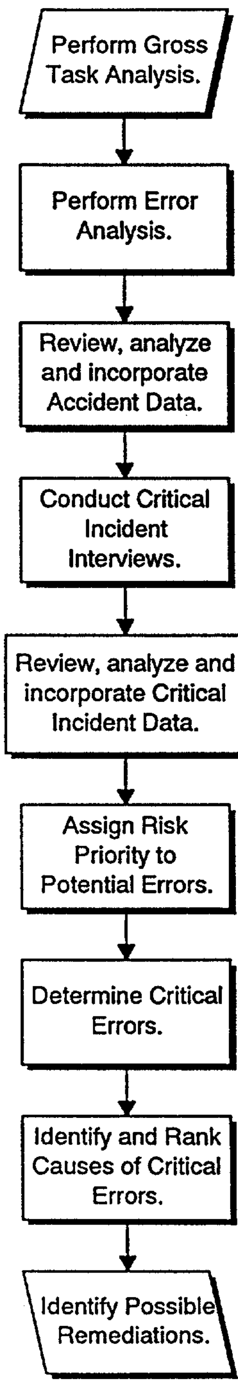
Procedures (Cont.)	EC 3: Assess the Likelihood Not all possible causes of error are equally likely to occur. Since the cost of remedial measures can be quite high, it is important to identify those causes of error which are most likely to occur. Using Form 5, rate the likelihood of each cause of an error. Likelihood of Error Cause 1 2 3 4 5 Low Medium High Examples of Error Likelihood Ratings: Information Source; Background Noise, Siren Inaudible Average Likelihood Rating = 4.2 Record the average likelihood rating of team members on Form 5.
Remediation (R)	Remediation involves procedural changes, training, retraining and even changes to the individual activity task steps in order to avert or reduce potential for errors. In the case of the INFORMATION SOURCE being the error causation, training can be implemented to ensure that the human knows what information is needed in order to complete the task step and where to look for that information. Also, inappropriate information must be recognized, i.e., the human operator must know which information to pay attention to and which to ignore. If the information is received from a machine, the causes for why that information was not available must be researched and if the capability exists for an information display to be present, with a minimum of investment, the possibility for that display presence should be investigated. INPUT CHANNEL errors are those in which the information is present, but the quality of the signal is disrupted. This can apply to both human and machine. The human error can stem from the information not being received correctly due to some environmental disturbance, like too much noise or inclement weather. The machine providing the information can also be at less than perfect transmission. Researching the causes for why the information was disrupted, distorted or delayed can help identify where to target the assistance for efforts aimed at both human and machine. If an outside factor, not under one's control, like the weather or noise, is the culprit in this phase of information processing, then contingency plans may have to be implemented where assumptions and backup plans are instituted in the case of incomplete or distorted information.

Remediation (Cont.)	Where the INFORMATION PROCESSOR is seen as the cause of the error, the majority of the failures will come from the human psychological or physiological shortcomings. In the category of psychological, things to pay attention to are: Memory loading - are we asking the human operator to remember too much information? Learning problems - is our training sufficient Attention - is the information prominent enough and recognized as the element the human must attend to? Motivation - is our employee motivated to do his/her job? Is the workload too high? Can we off-load some of the processing to the machine? Situation awareness - is the worker aware of the environment in which he/she is working? Is sufficient training provided to allow the worker to know where/when to look for information that is critical to the correct completion of a task? If a physiological problem could be at the root of an error in information processing, the sources would be in the human operator's level of - fatigue - stress - life requirements/obligations - fitness for duty in terms of drugs or alcohol abuse For remediation where physiological factors are to blame, screening may be required to evaluation life requirements and fitness for duty. Where fatigue and stress may be the cause, the remediation would be an evaluation of workload requirements, job responsibility and adequacy of rest breaks and shift schedules. In the case of OUTPUT CHANNEL being the malefactor in the cause of a critical error, the information processed by the operator may have again been disrupted, distorted or delayed before leading to an action. Here, the remedial solution would lie in assuring the correct output is selected through appropriate training in the cause and effect. If the environment plays a contributing role to the distortion or delay, all measures should be investigated which would minimize the impact of the outside factors like noise, vibration and insufficient illumination.

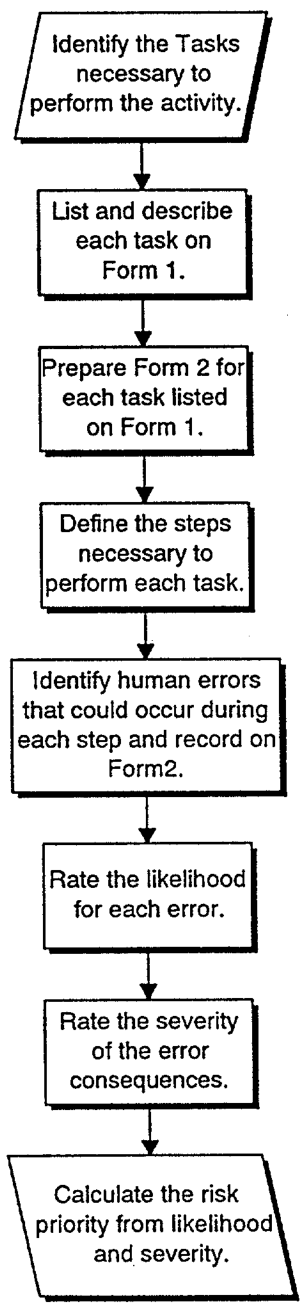
Remediation (Cont.)	The final stage where information processing can go amiss is in the OUTPUT ACTION phase. In this case, the human operator chooses the incorrect action, given the information present. An inaccurate, inappropriate or untimely action can be remedied through training and procedures review.
Contingency Planning (CP)	Contingency or emergency planning is necessary. This would involve reviewing the critical errors possible in the operations, tasks and steps. Where those errors are frequent or will result in severe injury or death or loss of equipment, emergency procedures must be developed, trained and implemented. It is important to review the contingency plans on a periodic basis to update their requirements, as procedures may change or operations may be altered, redesigned or superseded.

FLOW CHARTS

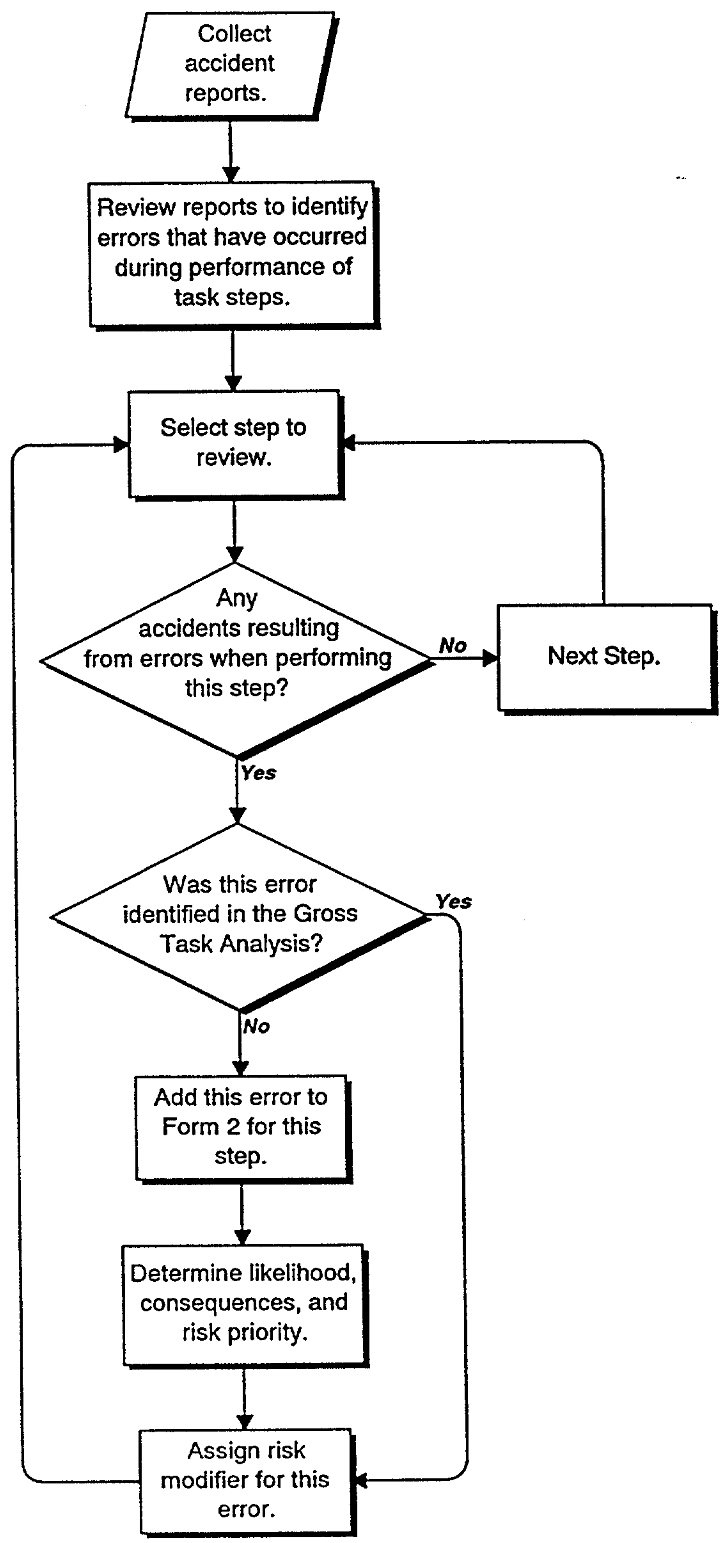
Human Error Potential Assessment
HEPA



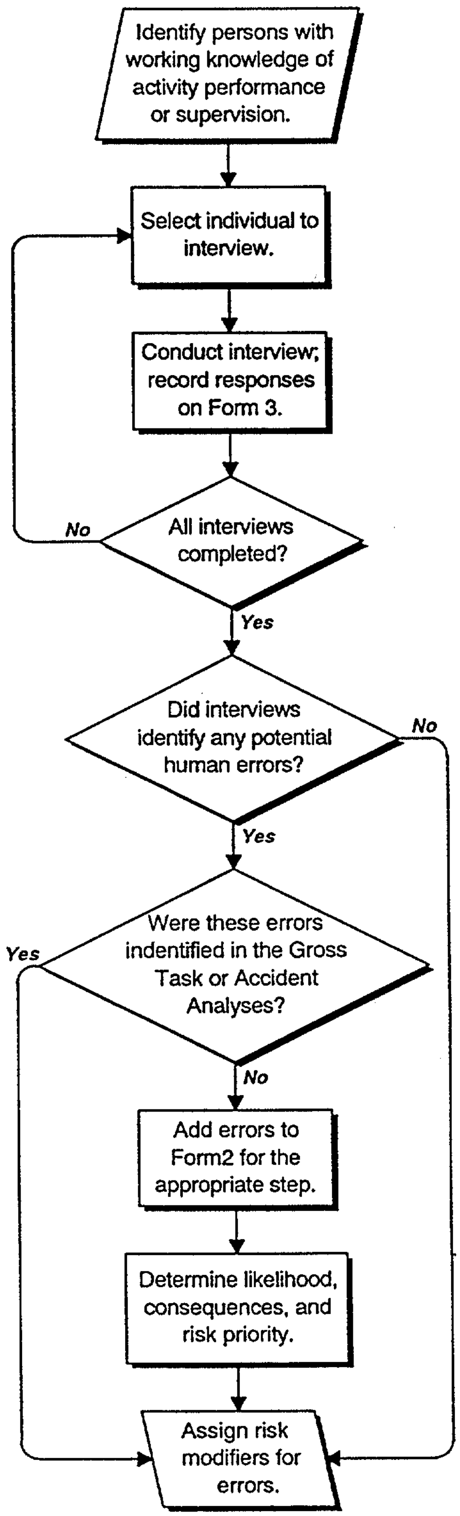
Gross Task Analysis



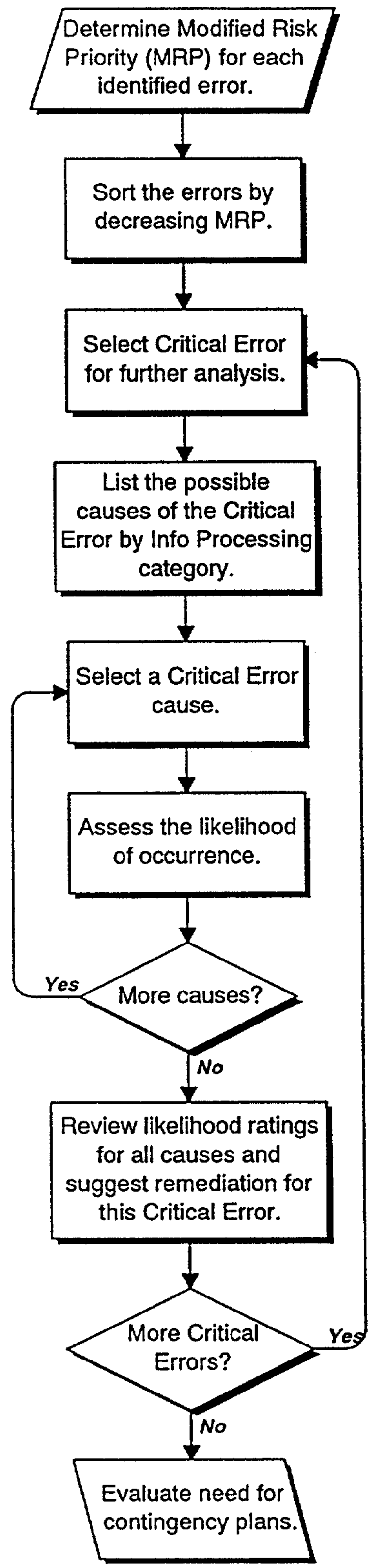
Accident Analysis



Critical Incident Interviews



Identify Critical Errors, Their Causes, and Possible Remediations



FORMS

Form 1 - Description of Activity

Date: ____________________

GROSS TASK ANALYSIS

Name of Activity	Description of Activity
Crane operations	Human, in conjunction with the crane, moves loads on and off the vessel and the off-shore facility.

Gross Task Analysis - Task Description

Task Name	Task Description
1.0 Position Crane to predetermined location.	Crane operator determines what load needs to be moved and positions the crane the pick up the load and move it.
2.0 Attach load	Crane hook is used to attach the load and secure it.
3.0 Lift load	Crane lifts the load up off the vessel or off-shore facility.
4.0 Move load	Load is moved to the desired final location.
5.0 Position load to predetermined location	Crane operator, with the crane, positions the load to the desired location on the vessel or on the offshore facility.
6.0 Release load	Hook is taken off the load. Load is now in new desired location.
7.0 Secure crane	Crane is turned off, controls locked and other procedures accomplished to secure crane.

Form 1 - Description of Activity

Date: ____________

GROSS TASK ANALYSIS

Name of Activity	Description of Activity

Gross Task Analysis - Task Description	
Task Name	**Task Description**
1.0	
2.0	
3.0	
4.0	
5.0	
6.0	
7.0	
8.0	
9.0	

Form 2 - Description of Steps in Tasks **Date:** ____________

Activity: ____________

Task Number and Name: 1.0 - Position the crane to a predetermined location

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	**Human Error Description**	**Likelihood of Error*** (1-5)	**Consequence of Error**** (1-5)	**Risk Estimate** (Col 3*4)	**Accident Risk Adjust***** (AccidentAnal)	**Incident Risk Adjust****** (Critical Incid)	**Modified Risk Value** (Larger of number in Col 6 or Col 7 * Col 5)
1.1 Select location to move crane	Wrong location selected						
1.2 Visually acquire location	Wrong location selected						
1.3 Operate crane controls to move/position lower crane	Incorrectly operate crane controls	2	4	8	1	2	16 (8 * Col 7 value)
1.4 Stop crane							

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - Description of Steps in Tasks

Date: ____________

Activity: ____________

Task Number and Name: ____________

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	**Human Error Description**	**Likeli-hood of Error*** (1-5)	**Conseq-ence of Error**** (1-5)	**Risk Esti-mate** (Col 3*4)	**Accident Risk Adjust***** (Accident Anal)	**Incident Risk Adjust****** (Critical Incid)	**Modified Risk Value** (Larger of number in Col 6 or Col 7 *Col 5)
n.1							
n.2							
n.3							
n.4							

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 3 - Critical Incident Interview Date: ____________________

Activity: ____________________

Task Number and Name: 1.0 - Position the crane to a predetermined location

Critical Incident Questions and Responses	
Can you think of a situation in which an accident occurred or almost occurred while performing this task?	Yes No
What were the general circumstances leading up to this incident?	
How often has this occurred?	
Exactly what did the operator do which contributed to the incident?	
When did this incident occur?	
What was the operator's job?	
How long has the operator been performing this task?	
What needs to be done to prevent this type of incident?	
What would you do if this type of accident occurred?	
Other comments?	

Form 4: CRITICAL ERRORS Analysis **Date:** ____________

** Critical Errors are those which have caused significant loss or if the value in Column 8 of Form 3 is "12" or above

Activity: ______________________________

Task: ______________________________

CRITICAL ERRORS ANALYSIS							
Step Number and Name	**Human Error Description**	**Error Causation Stage-Check all that apply**					**Comments**
		Info Source	Input	Info Processor	Output Channel	Output Action	
n.1							
n.2							
n.3							
n.4							

Form 5 - Description of Steps in Tasks

Date: ______________________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:

____

____

STEP TWO: EC2 — List Potential Error Causes

Source of error: ______________

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Potential Error Cause	Likelihood
1: ______________________	1 Low, 2, 3 Medium, 4, 5 High
2: ______________________	1 Low, 2, 3 Medium, 4, 5 High
3: ______________________	1 Low, 2, 3 Medium, 4, 5 High
4: ______________________	1 Low, 2, 3 Medium, 4, 5 High

Potential Remedial Measures
1.
2.
3.
4.

APPENDIX F

HUMAN ERROR ASSESSMENT OF OFFSHORE CRANE OPERATIONS COMPLETED FORMS

Form 1 - Description of Activity

Date: 3/1/97

GROSS TASK ANALYSIS

Name of Activity	Description of Activity
OFFSHORE CRANE OPERATIONS	1) MOVE LOADS ON PLATFORM (TOP DECK AND BETWEEN DECKS) 2) MOVE LOADS FROM PLATFORM TO SERVICE VESSEL. 3) MOVE LOADS FROM SERVICE VESSEL TO PLATFORM.

Gross Task Analysis - Task Description

Task Name	Task Description
1.0 DETERMINE LIFT REQUIREMENTS	
2.0 ASSIGN CRANE OPERATOR	
3.0 PREPARE EQUIPMENT AND CREW	
4.0 RIG UP CRANE	
5.0 POSITION CRANE OVER LOAD	
6.0 ATTACH LOAD	
7.0 LIFT LOAD	
8.0 POSITION CRANE FOR LOWERING LOAD	
~~9.0~~ 8.0a POSITIONING LOAD WITH A SIGNALMAN	

Form 1 - Description of Activity

Date: 3/1/97

GROSS TASK ANALYSIS

Name of Activity	Description of Activity

Gross Task Analysis - Task Description	
Task Name	**Task Description**
~~1.0~~ 9.0 LOWER AND UNHOOK LOAD	
~~2.0~~ 10.0 RIG DOWN CRANE	
~~3.0~~ 11.0 SECURE CRANE	
4.0	
5.0	
6.0	
7.0	
8.0	
9.0	

Form 2 - Description of Steps in Tasks Date: 3/1/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 1.0 DETERMINE LIFT REQUIREMENTS

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust*** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 RADIO CALL FROM CAPTAIN	DON'T RECEIVE CALL	4	1	4			4
n.2 DETERMINE TIME FRAME FOR LIFT	INCORRECT VESSEL ETA GIVEN	4	1	4			4
n.3 SPECIFY LOAD PARTICULARS.	INCORRECT LOAD WEIGHT SPECIFIED	4	2	8			8
	INCORRECT PACKAGING TYPE SPECIFIED	1	1	1			1
	INCORRECT LOAD SEQUENCE SPECIFIED	1	1	1			1
n.4 DETERMINE NEED FOR RIGGERS ON BOAT	RIGGER NEEDS SPECIFIED INCORRECTLY	1	1	1			1

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - Description of Steps in Tasks Date: 3/1/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 2.0 ASSIGN CRANE OPERATOR

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust*** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 ASSIGN CRANE OPERATOR	ASSIGN UNQUALIFIED OP	3	2	6			6
	ASSIGN UNAVAILABLE OP	2	1	2			2
	ASSIGN UNWILLING OP	3	1	3			3
n.2							
n.3							
n.4							

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High

** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives

*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents

**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - Description of Steps in Tasks

Date: 3/1/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 3.0 PREPARE EQUIPMENT AND CREW

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust*** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 SPECIFY RIGGING REQUIRED FOR LIFTS.	INCORRECT RIGGING SPECIFIED	1	1	1			1
	TAG LINES NOT SPECIFIED	4	2	2			2
n.2 CONDUCT PRE-LIFT CRANE INSPECTION	PRE-LIFT INSPECTION NOT CONDUCTED	4	3	12	3		24
n.3 IDENTIFY ON-PLATFORM LIFTS REQ'D. TO BOAT ARRIVAL	FAILURE TO CLEAR DECK FOR LOADS	1	1	1			1
n.4 PERFORM NECESSARY ADMINISTRATIVE TASKS	ADMINISTRATIVE TASKS NOT COMPLETED	1	1	1			1

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 · Description of Steps in Tasks Date: 5/2/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 4.0 RIG UP CRANE

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust *** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 START CRANE	THROTTLE NOT OPEN	1	1	1			1
	EMERGENCY STOP ACTIVATED	1	1	1			1
n.2 RAISE BOOM	BOOM ANGLE TOO HIGH	2	2	4			4
n.3 POSITION CRANE OVER STINGER	BOOM NOT CENTERED OVER STINGER	3	1	3			3
	BOOM ANGLE TOO LOW	3	2	6			6
	FAILURE TO CHECK SWING AREA	2	1	2			2
n.4 SELECT LIFT LINE TO BE USED	SELECT THE WRONG LIFT LINE	2	1	2			2

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - Description of Steps in Tasks — Date: 3/2/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 4.0 RIG UP CRANE

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust*** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 LOWER THE HOOK	HOOK LOWERED TOO FAR	2	1	2			2
	HOOK NOT LOWERED FAR ENOUGH	2	1	2			2
	FAILURE TO SET SWING BRAKE WHEN REQ'D	1	2	2			2
n.2 "	LOWER THE WRONG HOOK	3	1	3			3
n.3 ATTACH STINGER	SAFETY LATCH NOT ENGAGED	2	1	2			2
n.4 ATTACH SLINGS OR BASKET	SAFETY LATCH NOT ENGAGED	2	1	2			2

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - Description of Steps in Tasks Date: 5/2/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 5.0 POSITION CRANE OVER LOAD

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likeli-hood of Error* (1-5)	Conseq-ence of Error** (1-5)	Risk Esti-mate (Col 3*4)	Accident Risk Adjust *** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 RAISE BOOM	SEE TASK 4.0						
n.2 POSITION CRANE OVER LOAD	SEE TASK 4.0						
n.3							
n.4							

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High

** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives

*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents

**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - [D]escription of Steps in Tasks **Date:** 3/2/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 6.0 ATTACH LOAD 1/3

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likeli-hood of Error* (1-5)	Conseq-ence of Error** (1-5)	Risk Esti-mate (Col 3*4)	Accident Risk Adjust *** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 LOWER HOOK.	SEE TASK 4.0						
n.2 REMOVE SLING FROM STINGER	LEAVE STINGER ON IN ROUGH SEAS	2	2	4			4
	STINGER HOOK TOO HIGH	3	1	3			3
	STINGER HOOK TOO LOW	3	1	3			3
n.3 RAISE HOOK	RAISE THE WRONG HOOK						
n.4 SWING CRANE TO SAFE LOCATION.	HOOK NOT RAISED HIGH ENOUGH						

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 [D]escription of Steps in Tasks Date: 3/2/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 6.0 ATTACH LOAD 2/3

Description of Steps in Individual Tasks - Error Analysis

Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	**Human Error Description**	**Likelihood of Error*** (1-5)	**Consequence of Error**** (1-5)	**Risk Estimate** (Col 3*4)	**Accident Risk Adjust***** (Accident Anal)	**Incident Risk Adjust****** (Critical Incid)	**Modified Risk Value** (Larger of number in Col 6 or Col 7 *Col 5)
n.1 ATTACH SLING TO LOAD	SHACKLE PIN TOO TIGHT	3	1	3			3
	SHACKLE PIN TOO LARGE	3	1	3			3
	SHACKLE EYE TOO SMALL	3	1	3			3
n.2	SHACKLE PIN TOO LOOSE	2	1	2			2
	FAIL TO STRAIGHTEN SLING LINES	2	1	2			2
	CANNOT ATTACH SLINGS	2	1	2			2
n.3 POSITION CRANE OVER LOAD.	SEE TASK 4.0						
n.4 LOWER THE HOOK	LOWER THE HOOK TOO LOW	2	2	4			4
	HOOK NOT LOWERED FAR ENOUGH	2	1	2			2

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High

** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives

*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents

**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 Description of Steps in Tasks **Date:** 3/2/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 6.0 ATTACH LOAD 3/3

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	**Human Error Description**	**Likelihood of Error*** (1-5)	**Consequence of Error**** (1-5)	**Risk Estimate** (Col 3*4)	**Accident Risk Adjust***** (Accident Anal)	**Incident Risk Adjust****** (Critical Incid)	**Modified Risk Value** (Larger of number in Col 6 or Col 7 *Col 5)
n.1 ATTACH SLING TO STINGER	FAIL TO ENGAGE HOOK SAFETY LATCH	2	1	2			2
	CANNOT ATTACH SLING TO HOOK	2	1	2			2
n.2 RIGGERS MOVE CLEAR OF LOAD	RIGGERS DON'T MOVE CLEAR	3	3	9	2		18
n.3							
n.4							

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High

** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives

*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents

**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - Description of Steps in Tasks Date: 3/2/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 7.0 LIFT LOAD 1/2

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust*** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 TAKE UP LINE SLACK	SLINGS WRAPPED AROUND OBSTACLES	3	2	6	3		18
	TENSION LINE BEFORE BOOM IS CENTERED	3	2	6	2	3	18
	SLACK TAKEN UP TOO QUICKLY	3	2	6			
n.2	WINCH UP THE WRONG LINE	3	2	6	2		12
n.3 CENTER THE BOOM	BOOM NOT CENTERED	3	2	6			
n.4 WINCH UP THE LOAD	WINCH UP IMPROPERLY RIGGED LOAD	2	3	6	3		18

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 Description of Steps in Tasks **Date:** 3/2/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 7.0 LIFT LOAD 2/2

Description of Steps in Individual Tasks - Error Analysis

Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust*** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 SWING BOOM CLEAR OF BOAT	DON'T SWING BOOM CLEAR	3	2	6			6
	LOAD NOT CLEAR OF OBSTACLES	3	2	6	2		12
	SWING BOOM WRONG DIRECTION	3	1	3			3
n.2	SWING BOOM TOO FAST	3	2	6			6
	SWING BOOM TOO FAR	2	2	4			4
n.3 RAISE LOAD ABOVE PLATFORM OBSTACLES	WINCH TOO HIGH W/O.O.S ANTI TWO BLOCK	3	2	6	2		12
	BOOM TOO HIGH W/O.O.S BOOM KICK-OUT	3	2	6	2		12
n.4							

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - [illegible]scription of Steps in Tasks **Date:** 3/2/97

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 8.0 POSITION CRANE TO LOWER LOAD

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust *** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 SWING LOAD OVER CLEAR AREA	BOOM ANGLE TOO LOW	3	2	6			6
	BOOM ANGLE TOO HIGH	3	2	6	3		18
	FAIL TO CHECK SWING AREA	2	1	2			2
n.2							
n.3							
n.4							

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - scription of Steps in Tasks

Date: 0/2/11

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 9.0 LOWER & UN-HOOK LOAD

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust*** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 WINCH DOWN THE LOAD	WINCH DOWN TOO FAST	3	2	6	2		12
	WINCH DOWN LOAD ONTO CROWDED DECK	3	2	6			6
n.2 RIGGER UN-HOOKS THE SLING	INSUFFICIENT SLACK IN LINE	2	1	3			3
	RIGGER FAILS TO SECURE SLING ROPES	3	2	6	3		18
	RIGGER IN UNSTABLE POSITION	2	2	4			4
n.3 CRANE OPERATOR UN-HOOKS THE SLING	FAILURE TO SET SWING BREAK	2	2	4			4
	CANNOT SET SWING BREAK	2	2	4			4
n.4 WINCH UP THE HOOK	SLING WRAPPED AROUND OBSTACLES	3	2	6	3		18
	WINCH UP THE WRONG LINE	3	2	6	2		12

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High

** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives

*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents

**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - scription of Steps in Tasks

Date: [illegible]

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 10.0 RIG DOWN CRANE 1/2

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust*** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 SWING OVER RIGGING STORAGE AREA	SEE PREVIOUS						
n.2 WINCH DOWN LINE							
n.3 DETACH SLING OR BASKET							
n.4 SWING OVER STINGER LAYDOWN AREA							

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - scription of Steps in Tasks

Date: ‿/2‿‿7

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 10.0 RIG DOWN CRANE 2/2

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likelihood of Error* (1-5)	Consequence of Error** (1-5)	Risk Estimate (Col 3*4)	Accident Risk Adjust *** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 WINCH DOWN LINE	SEE PREVIOUS ↓						
n.2 REMOVE STINGER							
n.3 WINCH UP							
n.4							

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - [D]escription of Steps in Tasks **Date:** ?/2/17

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: 11.0 SECURE CRANE

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	Human Error Description	Likeli-hood of Error* (1-5)	Conseq-ence of Error** (1-5)	Risk Esti-mate (Col 3*4)	Accident Risk Adjust *** (Accident Anal)	Incident Risk Adjust**** (Critical Incid)	Modified Risk Value (Larger of number in Col 6 or Col 7 *Col 5)
n.1 BOOM UP	SEE PREVIOUS						
n.2 SWING BOOM OVER CRADLE							
n.3 BOOM DOWN INTO CRADLE	MISS THE CRADLE	2	1	2			2
	BOOM DOWN TOO FAST	3	2	6			6
	FAIL TO LET OUT LOAD LINE	3	2	6			6
n.4 SHUT DOWN CRANE	FAIL TO SHUT DOWN CRANE	2	1	2			2

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High
** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives
*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents
**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 2 - scription of Steps in Tasks **Date:** 5/8/41

Activity: OFFSHORE CRANE OPERATIONS

Task Number and Name: POSITIONING LOAD WITH A SIGNALMAN

Description of Steps in Individual Tasks - Error Analysis							
Column 1	Column 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
Step Number and Name	**Human Error Description**	**Likelihood of Error*** (1-5)	**Consequence of Error**** (1-5)	**Risk Estimate** (Col 3*4)	**Accident Risk Adjust***** (Accident Anal)	**Incident Risk Adjust****** (Critical Incid)	**Modified Risk Value** (Larger of number in Col 6 or Col 7 *Col 5)
n.1 POSITION A RIGGER LOAD	RIGGER NOT POSITIONED PROPERLY	1	1	1			1
n.2 POSITION SIGNALMAN TO SEE LOAD	SIGNALMAN CANNOT SEE LOAD	1	1	1			1
n.3 SIGNAL CRANE OPERATOR TO POSITION LOAD	CRANE OPERATOR CANNOT SEE SIGNALS	4	1	4			4
	WRONG SIGNAL GIVEN	3	2	6			6
	UNRECOGNIZABLE SIGNAL	3	1	3			3
n.4 CRANE OPERATOR RESPONDS TO SIGNALS	WRONG RESPONSE TO SIGNAL	3	2	6			6
	OPERATOR MOVES LOAD TOO QUICKLY	3	2	6			6
	OPERATOR MISSES SIGNAL	3	2	6			6

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High

** Consequence of Errors: 1 - Lost Time; 2 - Equip Damage; 3 - Injuries & Major Equip Damage; 4 - Death, Severe Inj, Equip Loss; 5 - Loss of System & Lives

*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents

**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 4: ( )TICAL ERRORS Analysis **Date:** 3-2-91

** Critical Errors are those which have caused significant loss or if the value in Column 8 of Form 3 is "12" or above

Activity: OFFSHORE CRANE OPERATIONS

3.0

Task: PREPARE EQUIPMENT & CREW

CRITICAL ERRORS ANALYSIS

Step Number and Name	Human Error Description	Error Causation Stage-Check all that apply					Comments
		Info Source	Input Channel	Info Processor	Output Channel	Output Action	
n.1 CONDUCT PRE LIFT CRANE INSPECTIONS	FAILURE TO CONDUCT PRE LIFT CRANE INSPECTION			X MOTIVATION			OPERATOR MOTIVATED TO GET THE JOB DONE QUICKLY AND DISTRACTED BY OTHER DUTIES.
n.2							
n.3							
n.4							

Form 4: ***ITICAL ERRORS Analysis*** **Date:** 3/3/97

** Critical Errors are those which have caused significant loss or if the value in Column 8 of Form 3 is "12" or above

Activity: OFFSHORE CRANE OPERATIONS

Task: 6.0 ATTACH LOAD

CRITICAL ERRORS ANALYSIS							
Step Number and Name	**Human Error Description**	**Error Causation Stage-Check all that apply**					**Comments**
		Info Source	Input CHANNEL	Info Processor	Output Channel	Output Action	
n.1 RIGGERS MOVE CLEAR OF LOAD	RIGGERS DON'T MOVE CLEAR			X SITUATION AWARENESS			LOAD MAY SHIFT IN HEAVY SEAS WHEN CABLE SLACK IS TAKEN UP.
n.2							
n.3							
n.4							

Form 4: ***ITICAL ERRORS Analysis*** **Date:** 3-2-91

** Critical Errors are those which have caused significant loss or if the value in Column 8 of Form 3 is "12" or above

Activity: OFFSHORE CRANE OPERATIONS

Task: 7.0 LIFT LOAD

CRITICAL ERRORS ANALYSIS							
Step Number and Name	**Human Error Description**	**Error Causation Stage-Check all that apply**					**Comments**
		Info Source	Input Channel	Info Processor	Output Channel	Output Action	
n.1 RAISING THE HOOK (TAKE UP SLACK)	WINCH UP WITH SLING WRAPPED AROUND OBSTACLES	X	X				CANNOT SEE ALL AROUND LOADS OR OBJECTS ON DECK. MAY OCCUR AFTER VISUAL CHECK - JOB OR PROCEDURE REDESIGN
n.2 "	TENSION BEFORE BOOM IS CENTERED				X	X	DIFFICULTY TRACKING A MOVING TARGET.
n.3 "	WINCH UP THE WRONG HOOK				X		OPERATOR MAY SELECT WRONG LEVER
n.4 WINCH THE LOAD OFF THE DECK.	WINCH UP IMPROPERLY RIGGED LOADS	X					PROBLEM IS CREATED BY RIGGER SIGNALING TO RAISE.

Form 4: **TICAL ERRORS Analysis** **Date:** 3/2/91

** Critical Errors are those which have caused significant loss or if the value in Column 8 of Form 3 is "12" or above

Activity: OFFSHORE CRANE OPERATIONS

Task: 7.0 LIFT LOAD / LOAD

CRITICAL ERRORS ANALYSIS

Step Number and Name	Human Error Description	Error Causation Stage-Check all that apply					Comments
		Info Source	Input CHANNEL	Info Processor	Output Channel	Output Action	
n.1 SWING BOOM CLEAR OF BOAT.	SWING BOOM BEFORE LOAD CLEARS OBSTACLES ON BOAT		X	X		X	SLOW LOAD LIFT MAY CAUSE PROBLEMS AS BOAT SHIFTS.
n.2 RAISE LOAD ABOVE PLATFORM OBSTACLES.	WINCH UP TOO HIGH WITH O.O.S ANTI-TWO BLOCK.			X			OPERATOR WATCHING LOAD – NOT BALL OR BLOCK. SAFETY DEVICE INOPERABLE – SEE TASK 3.
n.3 "	BOOM UP TOO HIGH WITH KICKOUT O.O.S.			X			OPERATOR WATCHING LOAD – NOT BOOM ANGLE. SAFETY DEVICE INACTIVE SEE TASK 3
n.4							

Form 4: ***ITICAL ERRORS Analysis*** **Date:** 3-3-97

** Critical Errors are those which have caused significant loss or if the value in Column 8 of Form 3 is "12" or above

Activity: OFFSHORE CRANE OPERATION

Task: 8.0 POSITION CRANE TO LOWER LOAD

CRITICAL ERRORS ANALYSIS							
Step Number and Name	**Human Error Description**	**Error Causation Stage-Check all that apply**					**Comments**
		Info Source	Input	Info Processor	Output Channel	Output Action	
n.1 SWING LOAD OVER CLEAR AREA	BOOM ANGLE TOO HIGH			X			SEE TASK 7.0
n.2							
n.3							
n.4							

Form 4: [illegible]ITICAL ERRORS Analysis **Date:** 3-[illegible]-9[illegible]

** Critical Errors are those which have caused significant loss or if the value in Column 8 of Form 3 is "12" or above

Activity: OFFSHORE CRANE OPERATIONS

Task: 9.0 LOWER & UN-HOOK LOAD

CRITICAL ERRORS ANALYSIS

Step Number and Name	Human Error Description	Error Causation Stage-Check all that apply					Comments
		Info Source	Input CHANN.	Info Processor	Output Channel	Output Action	
n.1 WINCH DOWN THE LOAD	WINCH DOWN TOO FAST			X		X	
n.2 RIGGER UN-HOOKS THE SLINGS	RIGGER FAILS TO SECURE SLING ROPES			X			SLING ROPE CAN SWING AND STRIKE RIGGER
n.3 WINCH UP THE HOOK	SLING WRAPPED AROUND OBSTACLES	X					RIGGER SIGNALS TO RAISE
n.4 "	WINCH UP THE WRONG LINE				X		OPERATOR MOVES THE WRONG LEVER.

orm 5 - Description of Steps in Tasks

Date: 3-4-97

Instructions: Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:
FAILURE TO CONDUCT PRE-LIFT CRANE INSPECTIONS

STEP TWO: EC2 — List Potential Error Causes

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Source of error: INFO CHANNEL

STEP TWO: EC2 — List Potential Error Causes	STEP 3: EC3 — Rate the Likelihood of Each Potential Cause
1: ADVANCED NOTIFICATION OF BOAT ARRIVAL NOT RECEIVED	1 Low, 2, 3 Medium, (4) circled, 5 High
2:	1 Low, 2, 3 Medium, 4, 5 High
3:	1 Low, 2, 3 Medium, 4, 5 High
4:	1 Low, 2, 3 Medium, 4, 5 High

Potential Remedial Measures
1. a) PROVIDE BACKUP SHIP-TO-PLATFORM COMMUNICATION TO ENSURE ADVANCED WARNING IS RECEIVED.
2.
3.
4.

Form 5 - Description of Steps in Tasks

Date: ______________________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:

FAILURE TO CONDUCT PRE-LIFT CRANE INSPECTIONS

STEP TWO: EC2 — List Potential Error Causes

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Source of error: INFO PROCESSOR

Potential Error Cause	1 Low	2	3 Medium	4	5 High
1: WORKLOAD - TIME CONSTRAINTS	1	2	(3) circled	4	5
2: CONSEQUENCE SEVERITY IS PERCEIVED TO BE MINOR (IGNORED)	1	2	3	(4) circled	5
3:	1	2	3	4	5
4:	1	2	3	4	5

Potential Remedial Measures
1. ESTABLISH AND/OR ENFORCE PROCEDURE TO CONDUCT DAILY CRANE CHECKS DURING SLACK PERIODS.
2. IMPROVE TRAINING AND SUPERVISION. ESTABLISH MANDATORY CHECKPOINTS IN PROCEDURE TO "TICKLE" COMPLIANCE
3.
4.

orm 5 - *Description of Steps in Tasks*

Date: 3-4-97

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:

RIGGERS ON BOAT DON'T MOVE CLEAR AFTER ATTACHING LOAD

STEP TWO: EC2 — List Potential Error Causes	STEP 3: EC3 — Rate the Likelihood of Each Potential Cause
Source of error: INFO PROCESSOR	
1: INEXPERIENCED/UNTRAINED RIGGERS	1 Low, 2, (3) Medium [circled], 4, 5 High
2:	1 Low, 2, 3 Medium, 4, 5 High
3:	1 Low, 2, 3 Medium, 4, 5 High
4:	1 Low, 2, 3 Medium, 4, 5 High

Potential Remedial Measures
1. ENSURE AVAILABILITY OF TRAINED RIGGERS THROUGH MANPOWER PLANNING OR CONTRACT SPECIFICATIONS
2.
3.
4.

orm 5 - *Description of Steps in Tasks* Date: ______

Instructions: Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:
RAISE THE WRONG HOOK (WHEN ATTEMPTING TO TAKE UP SLACK)

STEP TWO: EC2 — List Potential Error Causes

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Source of error: OUTPUT CHANNEL

Potential Error Cause	Likelihood (1 Low – 3 Medium – 5 High)
1: CONFUSION BETWEEN LOAD LINE AND FAST LINE CONTROLS	1 Low, 2, (3) Medium [circled], 4, 5 High
2:	1 Low, 2, 3 Medium, 4, 5 High
3:	1 Low, 2, 3 Medium, 4, 5 High
4:	1 Low, 2, 3 Medium, 4, 5 High

Potential Remedial Measures

1. MODIFY CRANE CONTROLS TO ENHANCE CONTROL DIFFERENTIATION
2.
3.
4.

Form 5 - Description of Steps in Tasks

Date: ____________________

Instructions: Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:

SLING WRAPPED AROUND OBSTACLES (WHEN RAISING HOOK)

STEP TWO: EC2 — List Potential Error Causes	STEP 3: EC3 — Rate the Likelihood of Each Potential Cause
Source of error: INPUT CHANNEL	
1: CROWDED BOAT DECK (DISTORTION, DISRUPTION)	1 Low · 2 · 3 Medium · (4) · 5 High
2: INEXPERIENCED/UNTRAINED RIGGERS	1 Low · 2 · (3) Medium · 4 · 5 High
3: POOR ILLUMINATION (NIGHT OPS) (DISTORTION, DISRUPTION)	1 Low · 2 · (3) Medium · 4 · 5 High
4:	1 Low · 2 · 3 Medium · 4 · 5 High

Potential Remedial Measures
1. DEVELOP AND IMPLEMENT SPECIFICATIONS FOR CARGO SPACING ON BOAT DECKS.
2. ENSURE AVAILABILITY OF TRAINED RIGGERS THROUGH MANPOWER PLANNING OR CONTRACT SPECIFICATIONS.
3. INSTALL AND/OR MAINTAIN BOOM LIGHT SYSTEMS.
4.

Form 5 - Description of Steps in Tasks

Date: ______________________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:
TENSION APPLIED BEFORE BOOM IS CENTERED OVER LOAD

STEP TWO: EC2 — List Potential Error Causes

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Source of error: OUTPUT CHANNEL

Potential Error Cause	Likelihood
1: CONFUSION BETWEEN WINCH CONTROL AND BOOM CONTROL LEVERS	1 Low, 2, (3) Medium [circled], 4, 5 High
2:	1 Low, 2, 3 Medium, 4, 5 High
3:	1 Low, 2, 3 Medium, 4, 5 High
4:	1 Low, 2, 3 Medium, 4, 5 High

Potential Remedial Measures
1. MODIFY CRANE CONTROLS TO ENHANCE CONTROL DIFFERENTIATION.
2.
3.
4.

orm 5 - Description of Steps in Tasks

Date: ____________________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:

TENSION APPLIED BEFORE BOOM IS CENTERED OVER LOAD

STEP TWO: EC2 — List Potential Error Causes	**STEP 3: EC3 — Rate the Likelihood of Each Potential Cause**
Source of error: OUTPUT ACTION	
1: LOAD IS MOVING IN 3 DIMENSIONS (HIGH SEAS)	1 Low, 2, 3 Medium, (4) [circled], 5 High
2: BAD COORDINATION BETWEEN BOAT AND CRANE OPERATOR	1 Low, (2) [circled], 3 Medium, 4, 5 High
3:	1 Low, 2, 3 Medium, 4, 5 High
4:	1 Low, 2, 3 Medium, 4, 5 High

Potential Remedial Measures
1. DEVELOP AND IMPLEMENT CRITERIA FOR CONDUCTING LIFTS TO AND FROM SERVICE VESSELS IN HIGH SEAS AND ADVERSE WEATHER
2. PROVIDE CONTINUOUS HANDS-FREE COMMUNICATION BETWEEN CRANE OPERATOR AND BOAT CAPTAIN.
3.
4.

'orm 5 - Description of Steps in Tasks

Date: ______________________

Instructions: Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:

WINCH UP IMPROPERLY RIGGED LOADS 1/2

STEP TWO: EC2 — List Potential Error Causes

Source of error: INFO SOURCE

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Potential Error Cause	1 Low	2	3 Medium	4	5 High
1: IMPROPER SLING SELECTION		(2)			
2: SLINGS NOT PROPERLY ATTACHED INEXPERIENCED RIGGERS			(3)		
3: USING DAMAGED SLING. (FAILURE TO INSPECT SLING)		(2)			
4: FAILURE TO LOAD TEST NEW SLING BEFORE PLACING IN SERVICE		(2)			

Potential Remedial Measures

1.

2. ENSURE AVAILABILITY OF TRAINED RIGGERS THROUGH MANPOWER PLANNING OR CONTRACT SPECIFICATIONS.

3.

4. ESTABLISH AND IMPLEMENT AND/OR ENFORCE PRACTICE TO LOAD TEST ALL NEW SLINGS AT ON-SHORE FACILITIES BEFORE THEY ARE DELIVERED OFFSHORE.

orm 5 - Description of Steps in Tasks

Date: ______________________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:
WINCH UP IMPROPERLY RIGGED LOADS 2/2

STEP TWO: EC2 — List Potential Error Causes	STEP 3: EC3 — Rate the Likelihood of Each Potential Cause
Source of error: INFO SOURCE	
1: INCORRECT SLING ANGLE	1 Low, (2), 3 Medium, 4, 5 High
2: HOOK NOT ABOVE LOAD CENTER OF GRAVITY.	1 Low, 2, (3) Medium, 4, 5 High
3:	1 Low, 2, 3 Medium, 4, 5 High
4:	1 Low, 2, 3 Medium, 4, 5 High

Potential Remedial Measures
1.
2. DEVELOP SPECIFIC RIGGING PROCEDURES OR PRE-SLING FOR OFF-BALANCE LOADS (SUCH AS COIL TUBING MACHINES) THAT ARE FREQUENTLY LIFTED.
3.
4.

Form 5 - Description of Steps in Tasks

Date: ______________________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:
SWING BOOM BEFORE LOAD CLEARS OBSTACLES. (AFTER SNATCHING)

STEP TWO: EC2 — List Potential Error Causes

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Source of error: INFO. PROCESSOR

Potential Error Cause	Rating (1 Low, 2, 3 Medium, 4, 5 High)
1: SNATCHING HEAVY LOAD FROM BOAT USING SLOW LOAD LINE	1 Low (2) 3 Medium 4 5 High — 2 circled
2: LIFTING LOADS FROM VESSEL IN ROUGH SEAS.	1 Low 2 3 Medium (4) 5 High — 4 circled
3:	1 Low 2 3 Medium 4 5 High
4:	1 Low 2 3 Medium 4 5 High

Potential Remedial Measures
1. DEVELOP AND IMPLEMENT CRITERIA FOR CONDUCTING LIFTS TO AND FROM SERVICE VESSELS IN HIGH SEAS AND ADVERSE WEATHER
2.
3.
4.

ɔrm 5 - Description of Steps in Tasks

Date: ______________________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:
WINCH UP TOO HIGH (W/ O.O.S. ANTI-TWO BLOCK)

STEP TWO: EC2 — List Potential Error Causes

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Source of error: INFO PROCESSOR

Potential Error Cause	Likelihood (1 Low, 2, 3 Medium, 4, 5 High)
1: PRE-LIFT CRANE INSPECTION NOT PERFORMED	1 Low, 2, 3 Medium, (4) circled, 5 High
2:	1 Low, 2, 3 Medium, 4, 5 High
3:	1 Low, 2, 3 Medium, 4, 5 High
4:	1 Low, 2, 3 Medium, 4, 5 High

Potential Remedial Measures
1. a) PREVIOUS RECOMMENDATION b) ENFORCE PROHIBITION AGAINST USING CRANES WITH O.O.S ANTI-TWO BLOCK DEVICES
2.
3.
4.

orm 5 - *Description of Steps in Tasks*

Date: ______________________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:

BOOM UP TOO HIGH (W/ O.O.S. BOOM KICKOUT)

STEP TWO: EC2 — List Potential Error Causes

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Source of error: INFO PROCESSOR

1: PRE-LIFT CRANE INSPECTION NOT PERFORMED	1 Low	2	3 Medium	(4)	5 High
2:	1 Low	2	3 Medium	4	5 High
3:	1 Low	2	3 Medium	4	5 High
4:	1 Low	2	3 Medium	4	5 High

Potential Remedial Measures
1. PREVIOUS RECOMMENDATIONS.
2.
3.
4.

Form 5 - *Description of Steps in Tasks* Date: ______________________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:
WINCH LOAD DOWN TOO FAST

STEP TWO: EC2 — List Potential Error Causes

Source of error: INFO PROCESSOR

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

1: OPERATOR UNDER TIME CONSTRAINTS - RUSHED	1 Low	(2)	3 Medium	4	5 High
2:	1 Low	2	3 Medium	4	5 High
3:	1 Low	2	3 Medium	4	5 High
4:	1 Low	2	3 Medium	4	5 High

Potential Remedial Measures
1.
2.
3.
4.

orm 5 - Description of Steps in Tasks

Date: ______________________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:

WINCH LOAD DOWN TOO FAST

STEP TWO: EC2 — List Potential Error Causes

Source of error: OUTPUT ACTION

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Cause	1 Low	2	3 Medium	4	5 High
1: OPERATOR MOVES WINCH DOWN LEVER TOO FAR.	1	(2) circled	3	4	5
2:	1	2	3	4	5
3:	1	2	3	4	5
4:	1	2	3	4	5

Potential Remedial Measures
1.
2.
3.
4.

orm 5 - *Description of Steps in Tasks* Date: ______________

Instructions:	Use one copy of this form for each Critical Error Identified in HEPA Forms 1-4. In Step 2, identify all possible error causes, no matter how likely they may seem. In the final step, rate the likelihood of each error cause. Use the results to identify possible Remediation measures.

STEP ONE: EC1 — Describe the Critical Error

Critical Error:
RIGGER FAILS TO SECURE SLING ROPES (WHEN DETACHING LOAD)

STEP TWO: EC2 — List Potential Error Causes

STEP 3: EC3 — Rate the Likelihood of Each Potential Cause

Source of error: INFO PROCESSOR

Potential Error Cause	Likelihood (1 Low – 3 Medium – 5 High)
1: RIGGER NOT AWARE THAT SLING ROPES MAY BE FREE SWINGING.	1 2 (3) 4 5 — circled: 3 (Medium)
2: INEXPERIENCED / UNTRAINED	1 2 3 4 5
3:	1 2 3 4 5
4:	1 2 3 4 5

Potential Remedial Measures
1. ENSURE AVAILABILITY OF TRAINED RIGGERS THROUGH MANPOWER PLANNING OR CONTRACT SPECIFICATIONS
2.
3.
4.

APPENDIX G

REVISED HUMAN ERROR ASSESSMENT TOOL

TABLE OF CONTENTS

TABLES

FORMS

INTRODUCTION

The Human Error Assessment Tool (HEAT) is designed to allow teams of trained users to examine activities from a Human Factors (HF) perspective. The purpose of the HEAT is to identify possible system-induced human errors, prioritize these errors based on relative financial or safety impact, and analyze critical errors using an HF model in order to identify appropriate corrective measures for improving system performance.

SCOPE

Although the HEAT can be applied to any system, the goal of the JIP is to design a tool that is appropriate to the culture and resource availability of the offshore oil and gas industry.

LIMITATIONS

The HEAT is a systematic approach to analyzing an activity for human error. However, the user should not expect that application of human error assessment will identify and correct all possible sources of human error in a system. The value of human error assessment lies in the insight into the causes of human error that the analysis provides. This insight results in a unique perspective on how to modify an activity or system to reduce the potential for damaging human error.

Unfortunately, human error assessment cannot be used as the **single** tool for identifying system improvements. The HEAT compliments other hazard identification tools such as hazard and operability studies (HAZOP), fault tree analysis, event tree analysis, etc. The user will notice some similarities between the HEAT and these other hazard identification methods. When used appropriately and in conjunction with these other tools, human error assessment can help identify unique, cost-effective measures for system improvement.

GENERAL APPROACH

The approach involves examining the individual steps that people perform when conducting an activity in order to identify potential human errors. Once identified, each error is then subjectively analyzed and rated for its potential impact to system performance as well as its likelihood of occurrence. Rating the errors provides a means to prioritize the application of corrective measures for error reduction. High-priority, or critical, errors are the focus of the human factors error analysis, since eliminating these errors will result in the greatest overall system improvement.

Application of the HEAT involves three steps (Gross Task Analysis, Human Error Identification, and Error Analysis and Corrective Measures) that attempt to answer the following questions:

Gross Task Analysis

1. What is the activity of interest?
2. What are the major tasks performed in the activity?
3. What are the steps performed in each major task?

Human Error Identification

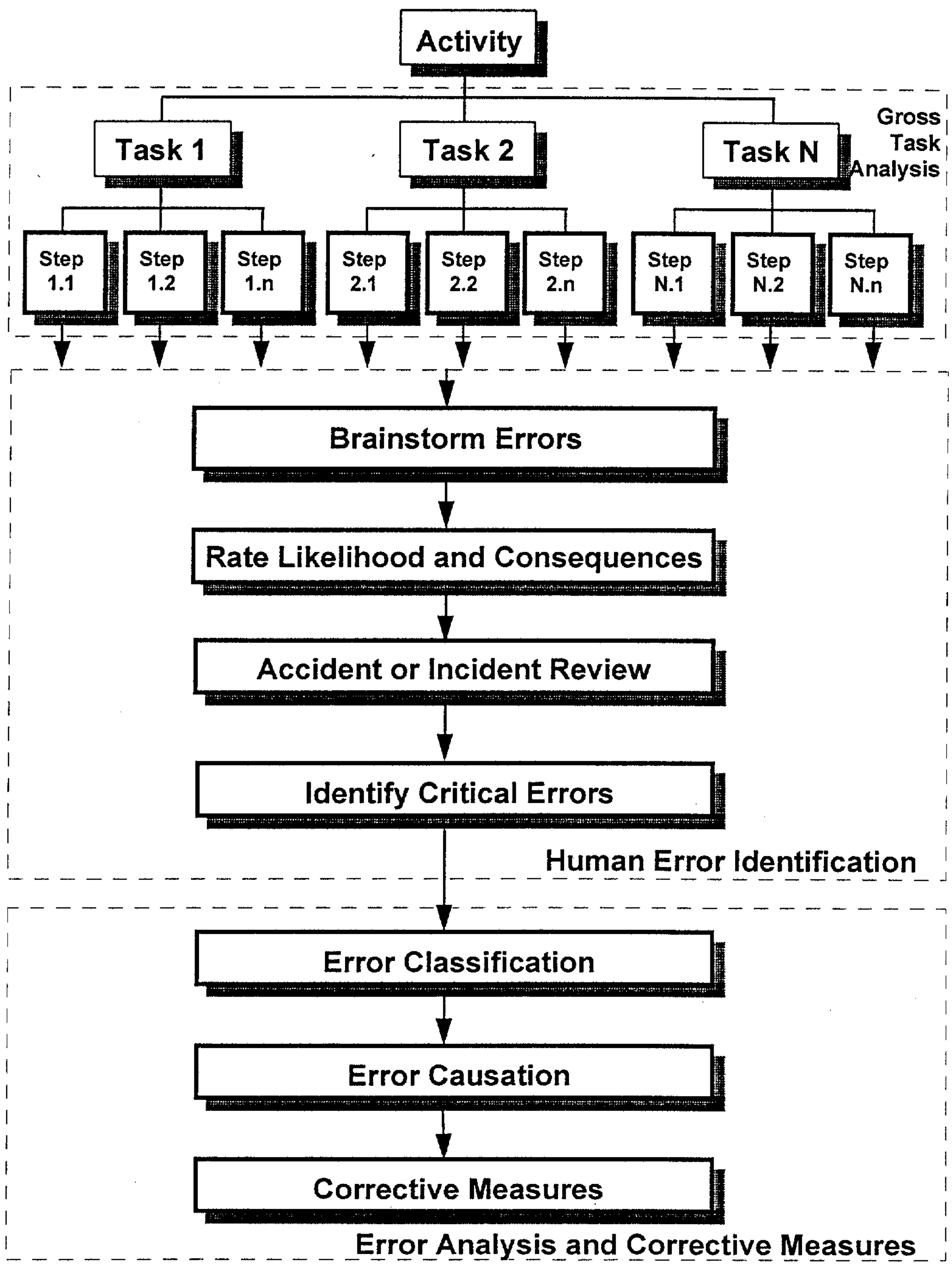
4. What are the potential errors for each step?
5. How likely is each error?
6. What is the consequence of each error?
7. Which are the critical errors?

Error Analysis and Corrective Measures

8. What are the human factors cause(s) these errors?

9. What are some appropriate corrective measures?

An overview of the of the HEAT is presented below:



Gross Task Analysis is used to develop an outline of the procedure that is followed when conducting the activity under study. If detailed written procedures are available for the activity, the Gross Task Analysis is not necessary as the procedures can be used directly in Human Error Identification.

Gross Task Analysis involves the following steps

- Define the study scope
- Break the activity down into tasks
- Break each task down into the steps needed to perform the task

Define Study Scope

Defining the study scope involves setting the boundaries of the activity to be studied. This can be done by identifying the initial and final state of the system. For example, consider the following initial state:

- Cargo basket located on the deck of a service vessel
- Platform crane shut down with boom resting in the boom cradle

And the following final state:

- Cargo basket located on platform deck
- Platform crane shut down with boom resting in the boom cradle

Based on the above conditions, the activity to be studied could be described as "moving a cargo basket from the deck of a service vessel to the platform using the platform crane." Since the initial and final condition of the crane is that it is shut down with the boom resting in the boom cradle, the activity scope will include crane startup and shutdown.

GROSS TASK ANALYSIS

Tasks	Tasks are the individual functions necessary to accomplish an activity. Tasks can be performed by either a human or a machine, separately or in combination. They represent the first level of the procedural outline and should be stated in broad terms. Some examples of tasks in crane operation are: • Position crane to a predetermined location • Attach load • Lift load • Position load to a predetermined location • Lower load • Detach load
Steps	Steps are the actions necessary to complete a task. The process of identifying steps is analogous to that of identifying tasks. Examples of steps involved in positioning a crane to a predetermined location are: • Select location to move crane • Visually acquire location • Operate crane controls to move/positions/lower crane

Gross Task Analysis Procedure

Resource Requirements	• An evaluation team of three or more people, at least one of whom is knowledgeable about the activity being analyzed. • Job or task descriptive information such as written procedures, written training materials, training videos, etc. • Meeting room • Flip chart with colored writing pens • White board with scanner (optional)
Preparation	If written procedures for the activity are available, these procedures can be used in lieu of the Gross Task Analysis. It may be appropriate to break procedures down into manageable tasks. This should be done by the team leader prior to holding the first team session. Copies of the existing procedure, broken down into the tasks, should be available for each team member.
	Discuss the activity to be studied with evaluation team members or management personnel. Define the initial and final state of the system.
	Record the activity description including the scope of the study on Form 1, "Human Error Assessment Summary."
	Using the check list on Form 1, determine which information and other resources are necessary to conduct the study.
	Obtain or generate the necessary information and resources prior to the initial evaluation team meeting.
	If the written procedures are to be used in lieu of the Gross Task Analysis, generate a task list prior to the first team session.

Gross Task Analysis Procedure

Identify Tasks	Discuss the activity with the subject matter experts. Evaluation team members should ask questions and thoroughly discuss the activity so that everyone on the team has a good understanding of the activity.
	If possible, the evaluation team members should observe the activity being conducted. A simulation such as a training video can also be used to familiarize all team members with the activity.
	Using a flip chart or white board, list the major tasks associated with the activity in the sequence order that they are normally performed.
Identify Steps	Transfer the first task to a blank flip chart page.
	List the steps required to complete the task in the sequence order that they are normally performed.
	Continue in the above manner until a list of steps has been developed for each of the identified tasks.

HUMAN ERROR IDENTIFICATION

The objective of Human Error Identification is to identify critical human errors that can occur during the activity under study. A critical error is an error that has an associated high risk index, which is a combination of both the likelihood of error occurrence and severity of the error outcome.

Identifying critical errors is accomplished via several techniques:

- Brainstorm possible errors associated with each procedural step
- Rate the likelihood of error occurrence and the most likely consequence to obtain a base risk index.
- Verify and expand the error list by reviewing historical accident data or interviewing additional personnel.
- Modify the base risk index based on the findings of the accident review or personnel interviews.
- Compare the modified risk index to an arbitrary cutoff value. Critical errors are those with modified risk indices greater than the cutoff value.

Brainstorm Errors

Human errors are identified by examining the requirements of proper step performance and then generating a negative statement for the requirement. For example, if the step requirement is "open valve A by 1/2 turn"

A person could make several errors such as:

- Operator closes valve A by 1/2 turn
- Operator fails to adjust valve A
- Operator opens valve A by an excessive amount

HUMAN ERROR IDENTIFICATION

Assign Risk Index	Once possible errors have been listed, the likelihood of making the error and the impact of making the error are rated. This rating process provides insight as to how tolerant a system is to error as well as how the system design (system being the hardware and organization support systems) influences error likelihood. Critical errors then become those errors that are: • Reasonably likely to occur • Not tolerated well by the system
Verify and Expand Error List	Brainstorming errors is subjective in that the results of the brainstorming session will be dependent on the knowledge and experience of the meeting participants. To ensure that error identification is as thorough as possible, the knowledge base can be expanded by: • Reviewing information on past accidents related to the activity • Interviewing additional personnel familiar with the routine performance of the activity Where accident data is available, reviewing this data is the most efficient way to verify the initial error identification. When such data is not available, interviewing 3-5 personnel that did not participate in the brainstorming will usually provide sufficient verification of the brainstorming results.

Modify Base Risk Index and Identify Critical Errors

The base risk index determined during the brainstorming is based on the likelihood and consequence ratings provided by the evaluation team. The accident data review or personnel interviews provide additional insight as to the likelihood and consequence of a given error.

To incorporate this new insight, the base risk index is modified by a factor that depends on the estimated frequency of occurrence during past operation. While this type of modification may not be appropriate for other types of hazard analysis, it is used here in order to more heavily weight system-induced errors which:

1. Are likely to happen

2. Can be reduced by modifying the system

Idiosyncratic errors, which are not system-induced, may account for a large number of the total errors that occur in a system. However, since these errors are more a function of the individual performing the activity, there will probably not be large clusters of the same error. System-induced errors, by definition, will occur with greater detectable frequency because they are an indication of a mis-match between human capabilities and the requirements of the system.

The risk index adjustment factor for each critical error is chosen based on the past frequency of occurrence for the error as follows:

1. Little or no previous accident or incident experience

2. Some previous accident or incident experience

3. Frequent previous accident or incident experience

Human Error Identification Procedure

Resource Requirements	• The evaluation team • Any available accident data for this activity • 3-5 personnel experienced in the activity (if interviews will be conducted) • Several copies of Form 2, "Gross Task Analysis and Error Identification"
Prepare Forms	For each task identified in the Gross Task Analysis, prepare one copy of Form 2, "Gross Task Analysis and Error Identification" by writing the task description in the appropriate location on the form.
Brainstorm Errors	Select a task.
	Enter the description of the first step under the subject Task in Column 1.
	Brainstorm human errors that can occur during the performance of the listed step. Enter each error into Column 2, one error per line.
Determine Risk Index	For each identified error, assign a rating for the likelihood of error occurrence in Column 3. The likelihood scale ranges from 1 to 5, with 1 being low likelihood and 5 being high likelihood.

	Enter a rating for the consequence of the error in Column 4. The consequence ratings range from 1 to 5 and have the following meaning: 1. Operational delays 2. Equipment damage 3. Injuries and/or major equipment damage 4. Severe injury fatality 5. Catastrophic event with possible multiple fatalities
	Calculate the base risk index by multiplying the likelihood rating (Column 3) by the consequence rating (Column 4). Enter the result in Column 5.
	When all errors identified for this step have been assigned a risk index, proceed to the next step for this task.
	When all steps for this task have been reviewed, proceed to the next task.
Accident Data Review	For each accident record, determine which of the previously identified errors was involved in the accident.
	If a human error that was not previously identified was involved in the accident, add the error description into the proper location on Form 2.
	Count the number of times each error was involved in an accident.
	Assign a risk index adjustment factor to each error based on the following scale: 1. Little or no previous accident experience 2. Some previous accident experience 3. Frequent previous accident experience

	Enter the adjustment factor in Column 6.
	Calculate the modified risk index for each error by multiplying the value in Column 5 by that in Column 6. Enter the result in Column 7.
Personnel Interviews	Using the interview guideline questions provided in Table 1, interview personnel regarding their past involvement with the activity. The goal of the interview is to determine the types of errors that people frequently make when performing the activity, regardless of whether the error resulted in an accident. These errors may have resulted in "near miss" incidents that were not formally documented.
	If a human error that was not previously identified was involved in the incident, add the error description into the proper location on Form 2.
	Count the number of times each error was involved in an incident or was brought up by interviewees.
	Assign a risk index adjustment factor to each error based on the following scale: 1. Little or no previous incident experience 2. Some previous incident experience 3. Frequent previous incident experience
	Enter the adjustment factor in Column 6.
	Calculate the modified risk index for each error by multiplying the value in Column 5 by that in Column 6. Enter the result in Column 7.
Identify Critical Errors	Review the modified risk index for each of the identified errors. If the modified risk index is 12 or more, classify the error as critical and review it using the Error Analysis and Corrective Measures Procedures.

Information Processing Model

The ultimate goal of the HEAT is to identify possible corrective measures for system-induced human errors. In order to develop effective corrective measures, specific causes of these errors must be understood.

In order for a person to successfully interface with a machine or processing system, the following must occur:

- The information required to prompt the operator to take an action must be available at detectable levels.
- The required information must be accurately received by the operator within the required time frame for action.
- The operator must interpret the information and choose the correct response.
- The operator must properly manipulate the machine or process to implement the correct response.

An information processing model can be used to classify human errors into the following categories that correspond to the above bullets:

- Information source errors
- Information reception errors
- Decision/response errors
- Action errors

ERROR ANALYSIS AND CORRECTIVE MEASURES

Information Source	Information sources provide data that the operator must receive in order to take appropriate action. Information sources can include both direct information from • the machine • an object • a signal person, or indirect information provided by • visual displays • auditory displays, etc.
Information Reception	Information reception includes both the transmission mode for the information as well as how the operator perceives the information. Transmission mode may include such items as line-of-sight to the information, background noise (when the information source is auditory), communication systems such as telephone or two-way radio, etc. Operator perception is via one or more of the five senses: sight, hearing, touch, smell, and taste.
Decision/ Response	Decision/response includes interpretation of the information based on memory, skills, attention, and higher level reasoning skills. It also involves selecting the correct response to the information based on all of the above.
Action	Action is the controlled movement of muscles to manipulate controls and affect the proper change to the system.

Error Classification

To better understand the causes of error, the error is classified based on the information processing model. The Error Classification Matrix in Table 2 relates the manifestation of an error (no action, late action, wrong action) to the information processing model via descriptive text. For example, if a person does not take required action, if may be for one or more of several reasons:

- The information needed to prompt the action is not available.
- The person does not receive the information due to a physiological limitation (receptor limitation) or an environmental disturbance that prevents or disrupts information transmission from the source to the receptor.
- The person ignores or mis-interprets information and, as a result, does not recognize the need for action.
- The person receiving the information does not have the ability or skill to perform the required action.

The value of error classification ultimately lies in identification of corrective measures designed to correct the faulty stage of information processing, thus eliminating the system-induced cause of error.

Error Causation

The Corrective Measures Matrix (Table 3) provides guidelines for developing corrective measures based on the error classification. The corrective measures suggested in this matrix are generic and must be considered in light of the specific activity under study.

A human error can result from one or more system-related causes. However, it is common that overall error occurrence is dominated by relatively few specific causes. As a result, it may not be necessary, or appropriate, to equally weigh each identified cause of error.

To focus resources on those causes that dominate error occurrence frequency, the HEAT requires the evaluation team to rate the likelihood of occurrence for each specific cause. Although it may be possible to suggest corrective measures for each cause, the greatest benefit toward error control will be achieved by focusing on high likelihood causes. The cutoff suggested by the JIP is to focus on causes with a likelihood rating of 3-5.

Error Analysis and Corrective Measures Procedures

Resource Requirements	• The evaluation team • All or the previously completed forms • Form 3, "Error Analysis and Corrective Measures" • Error Classification Matrix (Table 2) • Corrective Measures Matrix (Table 3)
Prepare Forms	Prepare Form 3, "Error Analysis and Corrective Measures," for each of the identified critical errors. Include the task in which the error occurs, the step in which the error occurs, a description of the error, and the modified risk index for the error.
Classify Errors per HF Model	Classify the errors according to the information processing model using the Error Classification Matrix (Table 2) on Form 3. Check all boxes in this matrix that apply to the identified error.
Identify Causes of Error	For each box checked in the error classification matrix, list the possible causes of the error on the bottom section of Form 3. Attach additional forms if necessary.
Rate Likelihood	Rate the likelihood that each specific cause will result in the error of concern. The likelihood ranges from a low of 1 to a high of 5.
Suggest Corrective Measures	Suggest appropriate corrective measures for each cause that is assigned a likelihood rating of 3, 4, or 5. The Corrective Measures Matrix (Table 3) provides guidelines for appropriate corrective measures based on the error classification. Corrective measures, whenever possible, should focus on correcting the <u>cause</u> of the error.
	Note any comments related to the cause or suggested corrective measure.

Table 1

PERSONNEL INTERVIEW GUIDELINES

Critical Incident Questions

1. Can you think of a situation in which an accident occurred or almost occurred while performing this task?
2. What were the general circumstances leading up to this incident?
3. How often has this occurred?
4. Was there some action or inaction by the people involved that contributed to the incident?
5. When did this occur?
6. What was your role in the activity?
7. How long have you been performing this task?
8. What needs to be done to prevent this type of accident?
9. What would you do if this type of accident occurred?
10. Other comments?

Table 2: ERROR CLASSIFICATION MATRIX

Information Processing Stage	Description of Stage	Information Processing Mechanisms	Type of Error		
			No Action	Late Action	Wrong Action
Information Source	Information provide data that the operator must receive in order to take appropriate action	Direct information from: Machine, object or person (sight, sound, movement, temp, smell, pressure, vibration) Indirect: Visual displays (gage, dial, lights, knob position) Auditory displays (sirens, horns)	Sources Information not present or not detectable (below human sensory threshold)	Source information not present at right time	Source information incorrect
Information Reception	Source information must be received by accomplished by specialized human sensory mechanisms • Transmission of information from the information sources to the human receptor • Proper reception of the information by the receptor	Sense: Vision - color, hue brightness, line-of-sight Sound - pitch, loudness Touch - vibration, temp, pressure Smell, Taste, Body Position, and Movement	Information cannot be received by specific operator (deaf, color blind) Information cannot be received because of environmental conditions (noise, darkness, brightness, weather)	Information delayed because of difficulties in reception	Incomplete reception because of distortion, disruption or distraction
Decision/ Response	Information received is used to invoke rules of reasoning in order to select a response	Attention (determining which information received is important) Memory (of learned rules and experience) Comparison (of received information with expected) Response generation (selecting response and action sequence)	Information not attended to (distracted, fatigue) Information ignored (not considered important) Not aware of correct response (faulty learning or experience)	Delays in processing (high workload, fatigue, stress, physiological condition)	Selects wrong action (incomplete learning or experience) Selects wrong control device
Action	Controlled movement of muscles to effect a change in the machine or process	Ability (action in within the capability of individual) Skill (training and practice to perform action successfully) Endurance (can sustain action)	Action not within ability	Slow to act (lack of practice of experience)	Wrong sequence - timing errors (lack of skill) Cannot sustain action (lack of endurance)

Table 3: CORRECTIVE MEASURES MATRIX

Information Processing Stage	Type of Error	Possible Corrective Measure(s)
	No Action (E1)	
Information Source	1 Source information not present or not detectable (below human sensory threshold)	1 Provide information above detection threshold
Information Reception	2 Information cannot be received by specific operator (deaf, color blind) 3 Information cannot be received because of environmental conditions (noise, darkness, brightness, weather)	2 Define required personnel attributes in fitness testing 3 Control environment; seek another sensory receptor; make information redundant (more than one source)
Decision/Response	4 Information not attended to (distracted, fatigue) 5 Information ignored (not considered important) 6 Not aware of correct response (faulty learning or experience)	4 Reduce workload; improve rest cycles or shift pattern; provide pre-alerting signal before vital information is presented 5 Procedural training and supervision. Mandatory checkpoints - flag removal 6 Training and practice
Action	7 Action not within ability	7 Define required personnel attributes; fitness testing
	Late Action (E2)	
Information Source	8 Source information not present at right time	8 Improve information flow or communications. Improve task sequencing.
Information Reception	9 Information delayed because of difficulties in reception	9 Improve source intensity; reduce background interference
Decision/Response	10 Delays in processing (high workload, fatigue, stress, physiological condition)	10 Reduce workload; improve rest cycles or shift pattern; provide pre-alerting signal before vital information is presented; increase supervision
Action	11 Slow to act (Lack of practice or experience)	11 Improve skills with "hands-on" training or frequent drills
	Wrong Action (E3)	
Information Sources	12 Source information incorrect	12 Provide correct information
Information Response	13 Incompletely processed because of distortion, disruption, or distraction	13 Reduce demands of competing tasks; improve communications system; provide training for information priority
Decision/Response	14 Select wrong action (Incomplete learning or experience) 15 Selects wrong control device	14 Improve training; conduct frequent drills 15 Modify the control display or configuration to improve differentiation
Action	16 Wrong sequence - timing errors (Lack of skills) 17 Cannot sustain action (Lack of endurance)	16 Improve control sequence identification; conduct frequent drills 17 Define required personnel attributes; fitness testing; improve training; redesign job

Form 1: HUMAN ERROR ASSESSMENT SUMMARY

Study Scope
Describe the State(s) of System Prior to Conducting the Activity:
Describe the State(s) of the System at Completion of the Activity:
From the Above, Create a Concise Statement of Scope for this Human Error Assessment:

Evaluation Team
List the Names and Titles of the Evaluation Team Members. Circle the Name of the Evaluation Team Leader

Study Preparation Checklist

The following checklist can be used for study planning purposes. Check off items needed for the study and obtain before the first evaluation team meeting

Item	Required?	Arranged	Item	Required	Arranged
Team members			Copies of Blank Heat Forms		
Written Procedures			Accident Data for the Activity		
Training Materials			Access to Personnel for Interviews		
____________			Interview Guideline Questions (Table 1)		
____________			Error Classification Matrix		
____________			Corrective Measures Matrix		
Meeting Room					
Flip Chart w/ Pens					
White board w/ Scanner					

Form 2: GROSS TASK ANALYSIS AND ERROR IDENTIFICATION

Activity: ____________________ **Date:** ____________

Task Number and Name: ____________________

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Step Number and Name	**Human Error Description**	**Likelihood of Error* (1-5)**	**Consequence of Error** (1-5)**	**Risk Index (3) * (4)**	**Adjustment Factor*****	**Modified Risk Index (5) * (6)**
______.____						
______.____						
______.____						
______.____						

* Likelihood of Errors: 1 - Low; 3 - Medium; 5 - High

** Consequence of Errors: 1 - Operational delays; 2 - Equipment Damage; 3 - Injuries and Major Equipment Damage; 4 - Death, Severe Injuries; 5 - Multiple Fatalities

*** Risk Adjustment Factor: 1 - No accident experience; 2 - Few Accidents; 3 - Frequent Accidents

**** Risk Estimate Adjustment Factor: 1 - No Incident Experience; 2 - Few Incidents; 3 - Frequent Incidents

Form 3: ERROR ANALYSIS AND CORRECTIVE MEASURES

Activity: ______________________ **Date:** ______________

Task Number and Description: ______________________

Step Number and Description: ______________________

Error Description: ______________________

Errors by Information Processing Stage

Check all that apply

Error / Stage	Information Source	Information Reception	Decision/Response	Output Action	Comments
No Action	1 ☐ Not present or below threshold	2 ☐ Operator limitation 3 ☐ Environmental interference	4 ☐ Inattention 5 ☐ Information ignored 6 ☐ Unaware of correct response	7 ☐ Lack of ability	
Late Action	8 ☐ Late availability	9 ☐ Delayed reception	10 ☐ Delays in processing	11 ☐ Delayed action	
Wrong Action	12 ☐ Incorrect information	13 ☐ Incorrect of incomplete reception	14 ☐ Selects wrong action 15 ☐ Selects wrong control device	16 ☐ Wrong sequence 17 ☐ Action not sustained or incomplete	

Cause of Error From Above	Likelihood of Cause Low Medium High	Possible Corrective Action (See Table)	Comments
	1 2 3 4 5		
	1 2 3 4 5		
	1 2 3 4 5		
	1 2 3 4 5		