Working Group 2

2nd International Workshop on Human Factors in Offshore Operations (HFW2002)

Effectively Including Human Factors in the Design of New Facilities

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April 8 – 10, 2002
Houston, Texas USA

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Abstract

Human error is a major cause of incidents in the offshore industry. For example, in the Gulf of Mexico region in 1998, 38% of all incidents were attributed to human error with an additional 9% of incidents resulting from slips, trips, and falls (MMS 2000-021, OCS Report). Human Factors, when integrated during the design of a new offshore facility, can reduce the potential for human error and the occurrence of unfortunate incidents.

Quite often the implementation of Human Factors (HF) during design is disregarded because of the notion that it will add unacceptable costs. Review of the cost/benefit data contained in this paper proves that notion to be untrue. Although cost/benefit is important, it was not the *primary* focus of this Working Group. This paper's focus is to develop a means or a strategy to effectively integrate the application of HF design principles into all phases of a new capital design project.

This Working Group's objective during the Second International Workshop on Human Factors in Offshore Operations was to generate discussion concerning HF integration strategies and to focus on specific implementation issues that have been shown to be successful. These include but are not limited to:

- The factors critical to the success of HF integration
- What HF activities should be conducted
- At what stage during the various design phases should HF activities take place
- HF strategies, how to decide what level of human factors engineering is required
- The qualifications and responsibilities of those executing HF activities

Effectively Including Human Factors in the Design of New Facilities

1.0 INTRODUCTION

1.1 What is Human Factors?

At a high level "human factors" (sometimes referred to as ergonomics) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance (IEA, 2000).

At a lower or more detailed level, "human factors" (as it relates to this particular paper) refers to a domain of specialization within the human factors discipline called physical human factors engineering. Physical Human Factors Engineering is largely concerned with human anatomical, anthropometric, physiological, behavioral, and biomechanical capabilities and limitations as they relate to human activity and the human-technology environment. Examples include, but are not limited to: workplace layout and design, working postures, materials handling, line of sight, repetitive movements, and safety.

A third practical working definition of Human Factors Engineering is the total effort put forth for analysis, design and verification and or evaluation of the work, facility, or item in question. Through repeated application of the cycle of these three components the design, operability, and maintainability of the work, facility, or item are improved to meet the needs of the user.

The practitioners of Human Factors Engineering fully recognize the importance and significance of the other domains of specialization within human factors, which also contribute to the reduction of human error in new system designs. These domains include cognitive and organizational human factors. Cognitive human factors topics include mental workload, decision-making, skilled performance, human-computer interaction, human reliability, work stress and training as these may relate to human-system design. Organizational human factors topics include communication, crew resource management, work design, design of working times, teamwork, participatory design, cooperative work, new work paradigms, virtual organizations, and quality management.

For a comprehensive application of human factors to a new system design ALL of the different domains of human factors will need to be incorporated into the system's design, construction, commissioning, and start-up.

1.2 What is the Cost and Return on Investment of Incorporating Human Factors?

Management has a legitimate concern that Human Factors Engineering (HFE) may add costs to the acquisition process through HFE requirements (e.g., those associated with design) and the expense of HF Personnel. However, HFE involvement in several recent offshore projects has demonstrated numerous instances where HFE inputs have reduced total acquisition costs (Miller and McSweeney, 2000).

How much does HFE really cost? In no case according to Miller (1999), who monitored the HFE costs over a nine-year period covering several offshore platform design and construction programs, did the total HFE program cost more than 0.12% (and consistently ran closer to 0.08%) of the acquisition cost of the platform. On the SABLE Project the original estimated cost (personnel charges only) for the HFE program was 0.07% of the facilities budget. The actual HFE cost for this project was 0.035% of the facilities cost, or half of the estimated cost.

HFE has a proven track record of returning many times the value of the initial investment throughout the operational life of a project. Miller (1999) reported that proposed HFE changes in the design of the riser tensioner system for an offshore platform lowered the system's construction cost by $242,000 as estimated by the company's engineers. This change was the result of a HFE review of the riser tensioner's maintenance/replacement requirements. Curole et. al. (1999) reported a case where HFE suggested modifications reduced the time required for the removal of a gas turbine from a compressor package enclosure. The maintenance time was reduced from 10 hours to 3 ½ hours approximately and the maintenance task is now conducted in a safer manner.

The overall availability or uptime of a facility is a function of the reliability and maintainability of both hardware/software and the reliability and efficiency of the personnel operating and maintaining the system. When the time required for maintenance can be reduced, especially for equipment that requires frequent maintenance or lengthy maintenance periods, as was the case with the removal of the gas turbine, it will improve the availability or uptime of a facility. The impact of each individual reduction in maintenance time may seem small. However, the sum of all maintenance time improvements in conjunction with increased system reliability, which is a function of a reduction in human error, will improve the availability of the facility. Based on historical data, Rensink and Van Uden (1998) discovered that for a typical $400 million petrochemical project, integrating HFE into a new plant design can result in a reduction of 0.25% in capital expenditure, 1% in engineering hours and 3% to 6% of the facility's life-cycle costs.

A review of company pre and post HFE involvement in offshore platform design also demonstrated the value of integrating HFE into new capital projects. As an example, the review of accident data (prior to the incorporation of HFE) on the offshore installations of one of the major operators in the Gulf of Mexico (GoM), revealed twenty-seven serious injuries over a five year period from falls down stairs and vertical ladders. This review effort resulted in a design specification for stairs, ladders and walkways based on HFE research data. This design specification was then used on subsequent offshore platforms and only one stair fall accident was recorded over the four-year period since the specification's introduction.

Curole et. al. (1999) reported that operators, maintainers, and the commissioning staff stated that the extensive HFE based labeling program (adopted by a major GoM Exploration and Production company) has been one of the most successful HFE improvements the company has incorporated. This HFE labeling program decreased the commissioning time of one facility by approximately three weeks.

However, it is pointed out here and in the following sections that the largest cost advantage will be attained when HFE is incorporated in advance of or concurrent with the design of the facility. Much of the cost advantage associated with the HFE effort will be lost if the designed or constructed facility must be changed to incorporate HFE recommendations.

1.3 What are the Benefits of Incorporating Human Factors in the Design?

As illustrated in the examples above, the return on investment in HFE can be quite substantial. It is also reasonable to expect that HFE can be applied to the offshore industry in a cost-effective manner. In general, some of the benefits that an operator might expect from a proactive HFE program include:

- Improved equipment design and controls that can result in fewer accidents, proper operation of equipment, and improved maintainability. This can generate improved up time for the facility, lower maintenance costs, improved personnel utilization, lower personnel exposure time and risk in hazardous areas as well as fewer incidents and near misses.
- Improved installation layout that can result in a better flow of personnel throughout the facility. This is especially important during emergency events. HFE could make the difference between a person living to tell of the incident, or not.
- Improved human-computer interface design for computer generated process, marine display and control screens. This can improve operator information processing and process control and alarm handling under both normal and upset conditions.

- Improved equipment and facility design can lead to improved human performance, less physical stress and fatigue, improved quality of work, and a work environment, which can improve worker satisfaction and morale.
- Equipment that is easy to operate and maintain through the provision of properly designed and easily understandable instructions, job aids, operating manuals, and procedures. An additional benefit is the potential reduction in personnel training time requirements.
- Reduced exposure to hazardous environments as a result of reduced maintenance and inspection times.

2.0 CRITICAL SUCCESS FACTORS FOR INTEGRATING HFE

The key ingredients for the successful integration of HFE during the various phases of a capital project are:

- Management commitment
- The support of people at all levels of the project organization
- Use of Human Factors Personnel
- User input during all project phases
- Early focus on known problem areas.

These factors will ensure that HFE is executed effectively and efficiently at every stage of the project. The critical success factors for the implementation of the HFE strategy are as follows:

2.1 Management Commitment

Management commitment can be exhibited in many ways beginning with project management's full support for HFE integration from the highest levels of project management. Some other examples of management commitment include:

- Appointment and empowerment of an HFE Champion - The HFE Champion acts as the company HFE representative on the project management team. The HFE Champion should be convinced of the benefits of HFE in design. Past offshore project experience shows that the HFE Champion should be in the Engineering Department, or, as a second choice, within the Operations Department. Placing the HFE Champion within a support group, such as Health, Safety and Environment (HSE) has not been as successful as when placed in Engineering or Operations. HF Personnel should be located in the same place organizationally. See 3.3.2.2 for further discussion on the HFE Champion.

- Early and continuous involvement of HFE throughout the project - It is extremely important to plan for and involve HFE from the Concept Phase of a project and to ensure continued involvement throughout the Operational Phase of the project. This will prevent late changes to the design at extra costs. It is essential to ensure that HFE is embodied in all phases of the project by integrating it into procedures and work methods of the company and contractor. HFE should be applied to the overall working-environment and human-machine interface design. HFE should be applied to the design of components and subsystems, as well as during the integration of the various subsystems into the total system.
- Develop an HFE integration strategy for the company and require an implementation plan from the contractors – Human Factors Engineering Plans (HFEPs) must be developed by the company and/or contractors describing their respective scope of HFE work to be completed for the project, the deliverables, schedule, organizational structure, and responsibilities of those involved including subcontractors and vendors.
- Mandate HFE in design – It is imperative to the success of a HFEP that HFE be mandated in the design through the inclusion of relevant HFE design standards or design requirements in the project specification.
- HFE Performance – HFE should be a focused activity and project management should actively track the effectiveness of the overall HFE effort as it does for other engineering disciplines.
- Use HF Personnel – Project management should ensure that HF Personnel are involved and are an integral part of the design team. HF Personnel should be continually involved throughout all the project phases to provide real time HFE input to engineers, designers, and draftsmen during system design or supervise and/or audit the HFE activities and deliverables of contractor personnel assigned HFE tasks.
- Organizational structure – Project management should physically and organizationally locate the HFE activity such that it promotes interaction between HFE, Engineering, Operations and HSE. The optimal location of HF Personnel would be under Engineering with Operations as a good second choice. Incorporating HFE under HSE is least preferred as HFE's ultimate customer is Operations and close cooperation between these two groups should therefore be generated. Whenever feasible HF Personnel should fall under the operating company to ensure that the highest level of commitment supports their effort. This does not preclude the contractor from also obtaining the services of HF Personnel.

- Resources – Project management should ensure that adequate resources are allocated towards HFE activities. Furthermore, HFE should be given the same consideration as other business/engineering demands in the planning and execution stages of day-to-day operations during the project's conception, design, and construction.
- Awareness training – Project management should commit resources towards HFE awareness training to the company project team, design agents, Operations and Maintenance personnel, inspectors, and vendors.
- HFE areas outside design – Project management can show their commitment through the requirement of HFE principles in areas outside of engineering design; i.e., personnel selection, staffing levels, shift work, and procedure/manual preparation.

2.2 Human Factors Personnel

With the decision made to include HFE, the relevant issue becomes the involvement of HF Personnel. Some companies and contractors believe that all that is needed for successful implementation of HFE into their design process is several days of HFE training for designers and engineers along with a set of HFE requirements (regulations, specifications, standards, checklists, procedures). It is also sometimes assumed that these HFE requirements would function in a similar fashion to the technical requirements of the project and will not require suitably qualified and experienced HF Personnel to take ownership of and ensure compliance with these requirements. These assumptions, along with the opinion that HFE is "common sense" and that "their designers have been doing it for years," will significantly reduce the effectiveness of the HFE program.

2.3 Relevant HFE Standards

The incorporation of HFE design requirements into project specifications is absolutely crucial to the successful design and integration of HFE in any new system. It provides for technical guidance and compliance without which the HFE effort will remain a "nice to have" at best or will have to rely upon the good intentions of the contractor/vendor. The importance of early availability of specifications, standards and requirements is also crucial to the total and consistent implementation of their content. Ideally these documents will be available during awareness training to provide attendees with the information and familiarize them with the documents content.

It is also extremely important that the HFE design inputs be based on the relevant standards such as the following:

- American Society for Testing and Materials. (2000). *Standard Practice for Human Engineering Design for Marine Systems, Equipment and Facilities* (ASTM F 1166 – 2000). West Conshohocken, PA: Author.
- American Society for Testing and Materials. (1991). *Standard Human Engineering Program Requirements for Ships and Marine Systems, Equipment and Facilities* (ASTM F 1337 – 2001). West Conshohocken, PA: Author.
- American Bureau of Shipping. (1998). *Guidance Notes on: The Application of Ergonomics to Marine Systems*. New York: Author.
- American Bureau of Shipping. (2002). *Crew Habitability on Offshore Installations*. New York: Author.
- NORSOK Standard. (1997). *Working Environment.* (S-002, Rev. 3)

Other project specific design requirements developed by HF Personnel.

Examples of such documents that have been developed for specific companies or projects in the past include the following:

- HFE Requirements for Offshore Living Quarters.
- HFE Requirements for Workplaces.
- HFE Requirements for Controls, Displays, Alarms, and Operator Panels/Consoles.
- HFE Requirements for Location and Orientation of Valves.
- HFE Requirements for Labels and Signs.
- HFE Requirements Ramps, Stairs, Vertical Ladders, Work Platforms, Walkways, and Railings.
- HFE Requirements for Computer Displays.
- HFE Guidelines for the Preparation of User Operational/Maintenance Manuals.
- HFE Specifications for Environmental Conditions in Enclosed Spaces.

Additional references are listed separately in Appendix A for use in obtaining information on specific topics. This list of references is not all-inclusive and only representative of the information available on HFE related topics.

2.4 Close Cooperation between Operations and HFE

The input of the end user, generally represented by Operations and Maintenance, is critical to the successful deployment of any new system and must be sought during every phase of the project cycle. By soliciting the opinions and knowledge of persons who have experience with systems, facilities, and equipment similar to that under design, many of the lessons learned by these individuals and information regarding strengths and limitations of the user population can be incorporated into the current design. It is also a commonly held belief that when users are involved in the design process their satisfaction with the end product is increased.

The cooperation between Operations and HF Personnel is the key in the determination of many design parameters and in the development of many project documents. The Operations personnel will provide HF Personnel with task information and data used to select appropriate HFE design guidelines and is integrated into competency profiles, staffing levels, procedure development, and other studies including HAZOPs and materials handling studies. HF Personnel are in turn advocates of Operations, providing them with support and guidance on issues pertaining to human capabilities and limitations. This information can influence the physical design of the facility as well as staffing levels, work scheduling, procedures, and materials handling as examples.

2.5 Early Focus on Known Problem Areas

The early focus should be on the analysis of known problem areas and lessons learned. Information sources that can identify these known problem areas include industry wide and company specific accident and incident reports and near misses, interviews with Operations and Maintenance personnel on similar existing facilities and equipment, and inputs from HF Personnel with offshore design experience. Where existing data is not available, a Front End Human Factors Engineering Analysis (FEHFEA) or a similar type of Gross Task Analysis should be conducted. This involves a multi-disciplinary team who identifies potential problems in the design of the human-machine-environment interface and ensures that these are addressed during the detail engineering design phase.

3.0 HOW TO INTEGRATE HUMAN FACTORS ENGINEERING (HFE) INTO THE PROJECT LIFE CYCLE, UP TO POST-COMMISSIONING AND START-UP

To ensure the effective integration and application of HFE design principles throughout the various life cycle phases of a capital project, a strategy is required which will establish management responsibility and accountability for HFE. The objective of this paper is to propose such a strategy. This can best be achieved by introducing HFE into existing project management systems with the prime objective of ensuring that the relevant HFE activities are executed effectively and efficiently at every stage of the project.

Once the appropriate level of HFE involvement in the project has been determined by project management, the critical points for bringing HFE activities into the project must be identified relevant to the project schedule. The attached Sample HFEP provides an overview of the high level activities associated with HFE and their relative time frames within a project. These activities follow the generalized life cycle model for HFE that requires the integration of analysis, design and verification, and evaluation.

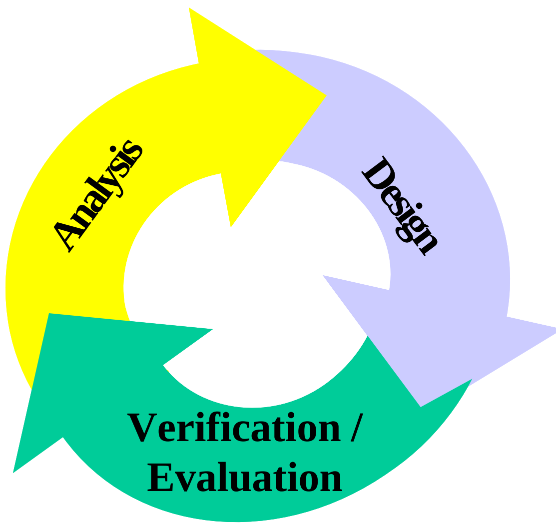

Figure 1. Life Cycle Model for HFE

Some of these activities have been expanded upon below:

3.1 HFE Vision and Policy Statement

The first step in the creation of a HFE Vision Statement is obtaining the approval and support for the implementation and integration of HFE into the new design project from senior management. This commitment on management's part should be included in a vision statement, which explains how

HFE will be addressed in relation to the project, within the company. This statement can be a stand-alone policy under its own HFE heading, or included as part of the Health, Safety, and Environment (HSE) policy statement.

The corporate or management level HFE vision statement should be related to a project level HFE mission statement. Similar to the corporate level statement, the project level statement will also require the approval and support of project management and discuss how HFE will be addressed in relation to the project.

A high degree of correlation between the two statements is required to ensure that the HFE desires of both levels of management are communicated compellingly throughout the project team and all phases of work. These two statements are supported by the project objectives.

Attached are Sample Vision, Mission and Objective Statements found in Appendix B. Note that these samples may not address all of the issues relevant to a specific project and that the terms of the project will also impact this statement.

3.2 Management and Project Team Orientation

Once the policy statement has been formalized, management and employees responsible for project execution need to be orientated to HFE, what it is and why it should be a part of a capital project. The Project Human Factors Engineering Plan (HFEP - Section 3.3.1.2), developed immediately upon management approval and support for HFE integration, should be introduced as part of this orientation as an outline of the required HFE tasks and how they integrate into the overall project. Such sessions are frequently called HFE awareness training sessions. Additionally, active support and involvement of line and project management is important to ensure successful implementation of the HFE strategy. Project managers, construction managers and line managers should be provided with knowledge about HFE principles and best practices and the added value of HFE as well as its tangible and intangible benefits.

Generally, the objectives of an awareness-training program are as follows:

- A basic knowledge of when and why human errors occur on offshore structures and onshore facilities
- A basic knowledge of HFE and why it should be applied during the project
- A basic knowledge of HFE design standards and how to use them
- Sufficient knowledge to recognize when and how to solicit HFE assistance when required.

The skill levels for different persons on the project team will generally be job specific and are addressed through the depth of training provided. A general overview for management training may require a two hour presentation to accomplish the objectives above, while a designer or engineer may require an eight hour training session to communicate the required level of understanding.

3.3 HFE Tasks/Activities

In the following paragraphs are listed typical activities performed by HF Personnel, from conceptualization to post-commissioning and startup phases of the project. These phases will obviously be different depending on the operating company or client. In order to perform some of these HFE Tasks/activities a number of HFE tools or techniques are mentioned. It is not the intention of this white paper to provide detail on these tools or techniques. The company is best served by having the techniques or tools applied by HF Personnel. .

3.3.1 Concept Phase (Define and Select)

3.3.1.1 Include HFE Requirements in the Project Specification(s)

During this phase detailed HFE design requirements that will accommodate the physiological, psychological and sociological characteristics of the anticipated end-user population must be included in the project specification(s) by those responsible for HFE on the project team. These specifications will also address the requirements that will initiate the HFE integration activities and tasks including operability assessments and verification. These requirements may take the form of calling out an HFE design standard such as ASTM F1166-2000 or the ABS Ergonomic Guidance Notes, or by developing and including company specific HFE design requirements in the project specification(s). The importance of early availability of specifications, standards, and requirements is crucial to the total and consistent implementation of these documents. Ideally these documents will be available during awareness training to provide attendees with the information and to familiarize them with the documents content. See Figure 2 and Figure 3 for examples of HFE requirements.

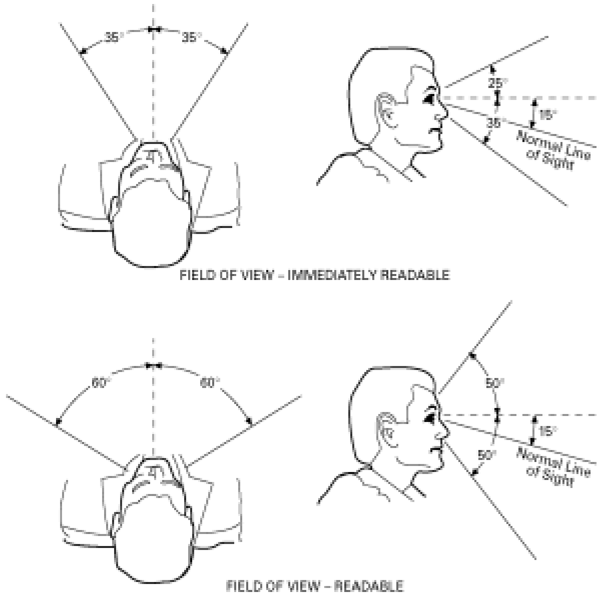

Figure 2. Operator Field of View

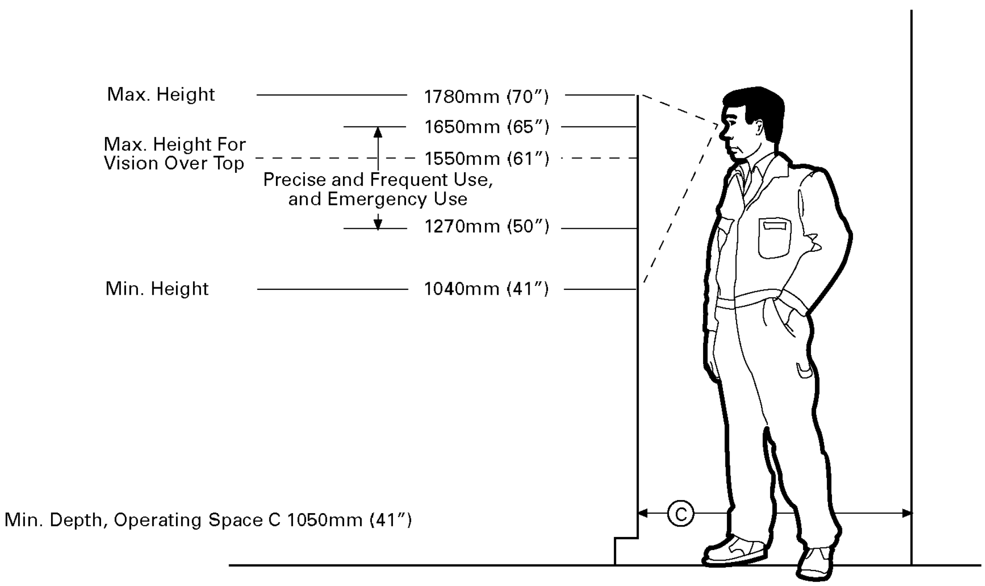

Figure 3. Multi-tiered Standing Console

(Figures used with the Permission of ABS)

Companies may also integrate (embed) specific HFE guidance and requirements directly into appropriate technical standards as opposed to separate HFE requirements or both. The project specifications should also include the scope of HFE work to be completed by the contractor as appropriate. It is important to have HF Personnel involvement during the project development as well as inclusion of HFE requirements into the project specification. This is largely because on any particular project there may be other factors that constrain the inclusion of certain HFE design requirements. Examples include: Operations may require the use of certain equipment, a specific process, or a design logic compatible with existing facilities, safety systems, etc. which may conflict with preferred HFE guidance (this most often happens when an existing facility is being expanded); contract terms, regulatory requirements, etc. may limit flexibility to implement certain HFE considerations, equipment choices, allowable suppliers, etc. It will therefore generally require HF Personnel to assist the project team in tailoring the HFE requirements for inclusion in the project specifications.

It should be noted that the importance of HFE integration activities, like operability assessments, are frequently underestimated and fail to be incorporated into the detailed design or feedback. Hazard and operability studies, which are commonly implemented in a project to address these issues, fail to cover the entire scope of operations in favor of review of the design philosophy that is easier to discuss. This failure has lead to the involvement of HF Personnel in other processes including 3D CAD and model reviews to address issues missed in the hazard and operability analyses.

3.3.1.2 The Project Human Factors Engineering Plan (HFEP)

The HFEP is a key part of the successful integration of HFE into a project. The HFEP should describe the scope of HFE work to be completed by each party, including the specific tasks and their relation to the project schedule, the deliverables, organizational structure, responsibilities of all parties involved, and vendor and subcontractor activities. Responsibility for developing the document can be assigned to the company, contractor or both parties depending on the contracting philosophy undertaken. In the case that the company assumes the responsibility for the HFE activities, the HFEP should be written by the company. In the case that the contractor assumes full responsibility for HFE activities, the contractor should write the HFEP as part of the bid package or as specified in the RFQ. There may also be the case where the company will develop an HFEP for the management of their own HFE activities that occur at a higher level than the contractor's HFE activities. In this case the company should define the concept for both HFEPs and the contractor should conform to the requirements therein. Irrespective of the author, the HFEP should be prepared as early as possible and upon management approval and support for HFE integration at the project level and assignment of the contract at the contractor level.

In any case the HFEP should be written prior to any awareness training. By having an approved HFEP prior to training, the implementation of the plan is secured and all members of the project team can be made aware of how HFE integrates into the project as a whole.

Attached is a sample HFEP found in Appendix C. It should be stressed that the HFEP does not include all of the topics covered by this white paper. The white paper addresses the strategy and philosophy for implementing HFE in a project while the HFEP is the process of implementing HFE in a project. In addition, there are topics covered by the white paper, which may be optional components of an HFEP, depending on the type and scope of a project.

3.3.1.3 HFE Participation During Conceptualization and Formulation of Philosophies

During this early stage of the project HF Personnel need to participate in all analyses that reach decisions and formulate philosophies regarding the health, safety and or environment of personnel as well as the operability, maintainability, and staffing levels of the facility. This may include control system, safety system, and emergency philosophies. HFE inputs must also be provided to the conceptual design and preliminary layouts in order to facilitate operability, maintainability, and to reduce the potential for human error.

3.3.1.4 Front End Engineering Definition (FEED)

During the Front End Engineering Definition (FEED), a Front End Human Factors Engineering Analysis (FEHFEA), Gross Task Analysis study (ASTM F1337 - 2001) or FEEEM® Design Analysis needs to be performed under the guidance of HF Personnel. The purpose of this task analysis and the analysis of lessons learned on similar existing facilities and operations input is to identify potential problems in the design of the human-machine interface with regards to the working environment. These analyses are also necessary to ensure that the potential problems previously identified are being addressed during detailed design. Certain critical facilities such as the Central Control Room, Driller's Control Cabin and the Offloading System will require a dedicated task analysis. Optimally studies such as these and operational and functional task analyses should begin shortly after the development of the process flow diagrams (PFD's). This timing will minimize the costs related to changes and schedule impacts and will allow the studies to continue smoothly during the detailed engineering design phase. Additional information on task analysis requirements is available in NORSOK S-002, Working Environment Standard (http://www.nts.no).

3.3.2 Detail Engineering Design Phase

3.3.2.1 Contractor Selection and Award

During the contractor selection and award process, the company, with the help of the HF Personnel, needs to evaluate contractor bid packages for the inclusion/integration of HFE requirements. The contractor should include in its bid package a Human Factors Engineering Plan (HFEP), when applicable, describing the scope of HFE work to be completed for the project, the deliverables, schedule, organizational structure and responsibilities of those involved including vendor and subcontractor activities. The information presented in these packages and the quality of the contractor HFEP provided (when applicable) is indicative of the contractor's capability in the area of HFE. The bid submittal should be reviewed for adherence to the HFE requirements included in the project specification. The evaluation must check the credentials of the contractor's proposed HF Personnel to ensure that they are qualified. Where HF Personnel are located within the contractor organization should also be considered and it is recommended that these persons be under the Engineering department, though Operations and HSE are also acceptable organizational locations. The physical location of this staff with regard to the remainder of the project team should also be considered. It is to the company's benefit for the HF Personnel to be co-located with the contractor's engineering staff.

3.3.2.2 HFE Champion

Project management must ensure that an HFE point of contact has been appointed within the company's project management team for each phase of the project. This point of contact is called the HFE Champion or HFE Accountable Person. The HFE Champion is most effective when this person has been appointed early in the project development and has approval authority covering most, if not all, items relating to HFE. Organizationally the HFE Champion and HF Personnel should be an integral part of the project team and they should be physically and organizationally located within the Engineering (preferred), or Operations (acceptable) department depending on the life cycle phase of the project. Past offshore project experience has shown that placing HFE Personnel in a support group, such as HSE, is not advisable but may work depending on where the HSE or support group representative reports to in the project organizational charts. Having HSE or the support group report to a project director will provide HFE with the support of senior project management.

3.3.2.3 Contractor HFE Awareness Training

Awareness training to contractor project management and an introduction to HFE training seminar to the contractor project management, engineering and design team must be provided before detail design begins. This training should include an introduction to all of the HFE activities to be performed during detail design and should describe what will be needed from the engineers and designers to accomplish those activities. Training should include presentations on the HFEP and design requirements, guidelines and checklists.

3.3.2.4 HFE Design Requirements, Guidelines and Checklists

The HFE design specifications included in the project specification are to be made available for use by designers and for inclusion in RFQs to vendors. It may be necessary to support these HFE design specifications with additional HFE guidelines and checklists subject to the approval of the company HF Personnel. HFE specifications may need to be tailored for specific vendor package RFQs. If required, company specific documentation such as standards, should be developed. Special documents should be developed prior to HFEP and awareness training for their inclusion in the appropriate documents.

3.3.2.5 HFE Action Item Tracking Database

HF Personnel should also document all HFE recommendations and design inputs made from the earliest point of HFE involvement and throughout all phases of the project. A database for keeping track of these HFE action items will allow for action item follow-up, closure, and for HFE progress reporting. Regular progress reports of HFE activities should be provided to project management.

3.3.2.6 Specific HFE Analyses and Studies

In order to properly support a design decision HF Personnel may be required to conduct specific HFE analyses. In some cases information is provided on human capabilities and limitations as input to studies conducted by Engineering, Operations and Maintenance (O&M), or other parties as required. Examples of such analyses and studies include:

- **Function allocation, task analyses and job descriptions** – The purpose of these HFE analyses is to identify which system functions are to be performed by equipment and which tasks are to be performed by personnel. For those tasks allocated to human operators, these analyses determine whether they are compatible with human physiological and psychological capabilities and limitations. Finally the tasks are grouped together and described as a single job or position, which serves as a major input for the determination of personnel competency profiles. HF Personnel will generally conduct these analyses though the data may be collected by other persons for analysis. Additional information on task analysis requirements is available in NORSOK S-002, Working Environment Standard (http://www.nts.no).
- **HAZOP's for key areas** – Hazard and Operability Studies (HAZOPs) are one of the most popular process hazard analysis techniques currently used in the offshore industry. The purpose of reviewing human factors within the HAZOP is to identify situations, equipment, or other factors which may result in human errors, thus creating process hazards, operational upsets, or maintenance problems. Once potential errors are identified, steps can be taken to control these deficiencies. The HAZOP team is composed of personnel representing the required engineering and technical disciplines who have experience with the primary hazards of the facility's processes. While human factors must be addressed during the HAZOP, it is not generally a required engineering discipline to be represented on the HAZOP team. The HAZOP team will be placed at a disadvantage if there is a lack of representation of HFE skills and knowledge on the team. This can result in the misapplication of training or procedural changes, or to the misapplication of equipment changes to control or correct for human error potentials and human performance related issues. HF Personnel should participate in the pre-HAZOP review of documentation such as layout drawings and piping and instrumentation diagrams/drawings (P&IDs). With the support of Operations and Maintenance personnel, HF Personnel will define the tasks that an operator would be expected to perform and which tasks would be assigned to equipment. During the HAZOP all issues that have HFE implications should be noted in the HAZOP record. An important mechanism to identify HFE concerns is the team's discussion of causes of deviations from the system intent along with the identification of the root causes of these deviations.

Whenever the potential for human error is identified during a HAZOP study, the team should discuss how and why such an error could occur and ensure that the HAZOP record documents the source(s) of such errors. HF Personnel should review the identified concerns as well as the suggested safeguards/controls and recommendations. This HFE activity is to ensure that the recommendations will reduce the probability of the error or reduce the consequence of the error to acceptable levels. Following the study HF Personnel may also need to perform additional analysis to evaluate the extent of identified HFE problems and their control.

- **Valve Criticality Analysis (VCA)** - The purpose of this study is to classify and then locate all valves used on a facility based on their criticality. The classification is based on a formal set of criteria agreed upon by all relevant members (disciplines) of the Engineering, Design, Operations, and Maintenance teams. The major benefit of the VCA is that it formalizes the decision process for determining the location (accessibility) of all valves. It also provides clear guidance to designers, speeds up the overall design review process, and alleviates unnecessary lengthy discussions on valve locations as the design progresses to completion. Additionally, the VCA ensures that operational and maintenance requirements are addressed when deciding on the location of a valve and this process generally reduces the cost of over-design. An example of this utility is the elimination of unnecessarily long piping in order to make valves accessible from deck level or the provision of stairway access and work platforms for access to non-critical valves. HF Personnel participates in all criticality discussions and provides guidance on acceptable locations for valves of different criticalities.
- **Emergency egress, escape and evacuation** – The purpose of this study is to review the HFE requirements during an emergency on an installation. This will include analysis of the escape routes, muster stations, and the integrity of the temporary refuge, the survival crafts/lifeboats and fast rescue crafts. During an emergency the most critical aspects of operations are the communications to personnel of the hazardous event and the design provisions that have been included to ensure the integrity and visibility of the egress routes. This includes HFE inputs on: the frequency, type and magnitude of the tones utilized for the alarms; the color, frequency/intensity, and location of alarm lights; and the markings, lighting, protection/shielding (plating, grating or heat shields) and clear width of escape routes (especially for stretcher access). After the egress routes, the next most critical location is the muster point. This would normally be located in a temporary refuge and is a designated point for verifying that all personnel are accounted for before the final decision to abandon and evacuate is made. The critical HFE aspects of this location include access/egress for the normal compliment of personnel on the

installation, the size of the muster station (adequate enough in size to minimize claustrophobic fears or stress with full evacuation equipment on), the communications in the refuge area (clarity), heat / carbon dioxide accumulation and stress, physical protection against the accidental event, and proximity to survival crafts/lifeboats. Generally, a secondary muster point is designated on the installation and would require the same HFE specification as the primary muster area. The final safety critical system is the HFE aspects of the survival crafts (lifeboats) and their boarding/staging locations. Designers should ensure that the survival crafts have incorporated HFE considerations during design, testing, maintenance, and operations of this equipment. This would include ensuring cultural calibration of the seats/entrance and critical pieces of operating equipment in the boat, stretcher access, recovery of overboard personnel and operations and control of the lifeboat. The study is normally performed by the HSE Specialist with significant input from HF Personnel.

- **Material handling study** – The purpose of this study is to define the requirements for material handling, either mechanically assisted or manually, on the facility. It is conducted by engineering with inputs from HF Personnel to interpret design standards and provide additional design guidance as needed on human capabilities and limitations. This study is conducted largely to prevent injuries from manual materials handling activities and to reduce downtime during scheduled and unscheduled maintenance activities. The scope of this study may include the evaluation of material handling equipment, selection of materials handling equipment, validation of paths of movement and clearance for this equipment, and accessibility to equipment.
- **Crane study** – The purpose of this study is to optimize drop zones or laydown areas based on crane operator viewing angles from the crane cab. This is conducted by engineering with input from HF Personnel on operator eye positions based on the appropriate anthropometric dimensions as well as other relevant information on human visual capabilities and limitations. Crane studies may also include review of the operator interface controls, work environment evaluations, accessibility issues including ladders and handrails and review of operational procedures.
- **Control room study** – The purpose of this study is to focus not only on the control room layout and ambient environment, but also on all types of activities to be performed under both normal and abnormal conditions. The aim is to further identify any factors that may negatively affect the operator and other designated personnel's ability to detect deviations, diagnose the situation, and take action following a given abnormal situation in the process and the subsequent sequence of events. The weak points identified by the study are then used as a basis for design recommendations. The Control Room Study group/team should consist of a control

room operator, instrument engineer, process engineer and HF Personnel. The group should be led by HF Personnel who is familiar with the techniques or tools needed for the analysis and with experience in control room design. Additional personnel from specialized disciplines; e.g., electrical, HVAC, telecom, HSE and Human Resources may be required to participate for short periods during special topics of the study. (ISO 11064: *Ergonomic Design of Control Centres* can be used as a guideline. Additional references include: A *Method for Reviewing Human Factors in Control Centre Design* developed by the Institutt for Energiteknikk in Norway and available on the web-site of the Norwegian Petroleum Directorate (www.npd.no); and Ingstad and Bodsberg's (1990) *CRIOP: A Scenario-method for Evaluation of the Offshore Control Centre.)*

- **HAZOP's of critical operating procedures** The purpose of this exercise is to identify potential human error during critical operations as a result of poorly written operating procedures. One example of such critical operating procedures is pig launching/receiving. The study is conducted in the same fashion as a traditional HAZOP. This study is generally conducted by HF Personnel with input from Operations, Maintenance, and Engineering.
- **Competency profiles** – The purpose of creating competency profiles is to specify the job performance requirements of the personnel who will be using a new system. This profile can also be used as a basis for personnel selection, training, qualification, and placement. The competency profile defines human performance requirements, and can be compared with an engineering specification for facility equipment. Using competency profiles as a basis for selection eliminates much of the uncertainty in the selection and training process, and subsequently reduces the technical and commercial risks associated with employee attrition, failures during training, and human error. The purpose of competency profiles is to minimize the effort required to select, train, qualify and potentially upgrade personnel prior to start-up. The competency profile establishes the entry and performance requirements for employees, but does not define the employee selection process, the training process, or the qualification process outside the establishment of performance limits. The competency profile is the minimum standard required for employees in each job/position. The competency profile identifies *what* the end product should be: a qualified, skilled employee with the appropriate physical capabilities (e.g., visual and auditory) for each specific position. It does not identify *how* to recruit, train and qualify personnel in order to reach the desired competency. This study is generally performed by Human Resources Personnel or HF Personnel with the relevant training and experience with input from Operations, Maintenance, and Engineering.

A responsibility matrix outlining several of the tasks that are part of integrating HFE into the project is included in the Sample HFEP. This matrix indicates accountability, responsibility, review and comment and technical support needs.

3.3.2.7 HFE Requirements in Vendor Specifications

During procurement HF Personnel must ensure that HFE design specifications, guidelines or checklists are included in RFQs to vendors. Furthermore, HFE specifications for specific vendor package RFQs must be tailored by HF Personnel, if necessary. If required, HF Personnel develop company specific documentation. HF Personnel participate during the evaluation of vendor bid submittals to evaluate bid packages for inclusion/integration of HFE requirements and for adherence to these requirements.

A list of equipment and equipment systems is provided in Appendix F that addresses the HFE priority for that equipment or system as well as the specific area of HFE concern. This listing, while extensive, may not be complete for all projects and the project scope of work and HF Personnel should be consulted.

3.3.2.8 HFE Design Inputs

HF Personnel provide HFE design inputs to project engineers and designers during detail design of workspaces and facility layouts; including, for example, areas such as the control/monitor room, accommodation facilities and human-machine interface workstations or those areas identified during the FEHFEA or FEEEM® Design Analysis. The reasons that these design inputs must come from HF Personnel are: 1) they may result from HFE analyses and studies that have been conducted, 2) because there is no direct criteria available from the design standards, or, 3) the designers are often uncertain how to interpret a general HFE requirement and need assistance from HF Personnel. Assistance is required especially where there is a conflict between different HFE requirements, or between HFE and other engineering requirements.

3.3.2.9 HFE Participation in Design Reviews

HF Personnel should be a required participant in reviews of most drawings produced by the company, contractor and vendor engineering personnel. This review will allow HF Personnel to review the drawings for operability, maintainability, and accessibility as well as workflow. The introduction of the three-dimensional computer-aided design (3D CAD) has become a powerful tool to be used in conjunction with the 2D CAD drawings for this purpose. Consequently, it is important that HF Personnel be involved in all the appropriate 2D and 3D CAD design reviews, particularly the detail design reviews held at 30%, 60% and 90% of design completion. While it is recognized that not every project will make use of the 3D CAD technology, in cases where the option is available, HFE involvement is crucial.

3.3.2.10 HFE Inputs to Personnel Selection and Training Criteria

HF Personnel can assist the Human Resources personnel and Operations and Maintenance engineers by providing competency profiles for use in employee selection. In the absence of competency profiles HF Personnel must assist these persons with the entry and performance requirements for each job or position that has been identified for the new system. Entry requirements would typically include basic performance requirements, physical and psychological criteria (such as aptitudes and abilities), personality preferences (e.g., team orientation) and basic life skills (such as reading, problem solving and decision making). Performance requirements will typically include requirements common to all positions such as HSE awareness, PPE equipment operation or emergency operations (such as survival craft operation for emergency evacuation etc.). Each position will also typically require specific knowledge, skills and abilities required for job performance and these are generally grouped into job classes or duties; e.g., system operation, maintenance, administrative and logistics, HSE, etc. Some HF Personnel may be capable of providing inputs on how to recruit, train and qualify employees in order to reach the desired competency required, but these activities are generally best performed by suitably trained and experienced Human Resource specialists. The use of competency profiles or any other selection tools should be only with approval of company legal staff.

3.3.2.11 HFE Inputs to Operations and Maintenance Documentation

HF Personnel should review and provide HFE inputs during the development of operation and maintenance documentation, training devices and instructional material to ensure they meet HFE principles for design and usability. HF Personnel can also serve as a valuable source of information for these documents, because task analyses conducted as part of the HFE evaluation will yield a great deal of the information for procedures. In addition, HF Personnel can provide guidance on the usability of the material including informational content, layout, location, size, use of symbols and pictograms, etc., to ensure information is presented based not only on visual capabilities but also on psychological principles for human information processing.

3.3.2.12 HFE Inputs to Signs and Labeling

In addition to the content and design of the documentation and manuals, HF Personnel should be involved in the content and design of hazard warning signs, labeling programs and job aids. HF issues related to the design and content of these items include color, informational content, layout, location, size, use of symbols and pictograms. As with documentation, signs and labeling must take advantage of research on human capabilities and limitations to ensure that the intended message is clearly received.

3.3.3 Construction/Fabrication Phase

3.3.3.1 HFE Awareness Training to Construction Staff

At the start of the construction phase, those responsible for HFE must conduct HFE awareness seminars and special training sessions for the construction field staff (especially on-site inspectors) to develop a general awareness for HFE, to familiarize them with HFE integration efforts performed during the design phase, and to introduce them to the HFE problems that often are created during the construction phase.

3.3.3.2 HFE Inspections

HF Personnel must visit fabrication yards and construction sites in order to audit compliance to HFE design requirements and ensure that the HFE requirements considered during the engineering and procurement phases have been implemented as per design. These inspections would generally be held in conjunction with other HSE audits and inspections.

3.3.3.3 "Field Run" or "Field Installed" Equipment

HF Personnel must provide support during the installation of "Field Run" or "Field Installed" equipment to ensure compliance with project HFE design requirements. Additional verification of the application of HFE to the final installation will occur during the safety walk through inspections in which HF Personnel should participate.

3.3.4 Installation through Startup Phases

The opportunity to be involved in the installation, hook-up, commissioning and start-up of the facility will allow HF Personnel to observe these activities and will allow for the verification of the tasks and operational and maintenance procedures that were developed. The presence of HF Personnel during this time will allow HFE to be considered in the correction of problems identified, provide an opportunity for the generation of lessons learned from HF Personnel experiences and provide a better understanding of the practical methods used for performing common operations and maintenance tasks and procedures.

3.3.5 Operate Phase

When the facility is in operation, generally some form of feedback is required. Typically the following activities can be performed by those responsible for HFE as part of the API requirements for tracking operability in the first year:

- Conduct operability assessments at six months and one year. These assessments should be planned and their scope outlined during the commissioning and startup phase to address common operational and maintenance issues as well as problems and concerns that arise during the commissioning and startup activities
- Obtain operator feedback via written and personal interviews regarding HFE successes and failures relative to operability and maintainability
- Monitor accident/incident reports for the identification of HFE design deficiencies
- Develop a lessons learned file or database
- Review problems identified or modifications made and improve upon solutions.

The importance of the information gathered during operations cannot be understated. This information is invaluable to the designers, engineers and HF Personnel as feedback on the process and outcome of their efforts and provides a loop of continuous feedback as these personnel move from project to project.

4.0 DETERMINING WHAT LEVEL OF HFE INVOLVEMENT IS REQUIRED FOR A PROJECT

The question often arises with project managers as to what level of HFE involvement is applicable to their capital project. This is a reasonable question since capital projects can range from simple (e.g., replacement piping system with no design changes) to intermediate (e.g., addition of a new system such as a chemical injection skid to an existing facility), to major (e.g., design and construction of a new offshore platform). The type and number of HFE activities on any single capital project should be appropriate to the size and magnitude of the project including its complexity, whether or not it has a predecessor facility, the degree of similarity between the new and existing facilities operated by the company, and which, if any, HFE activities were performed on the previous facilities.

Simple acquisition projects that represent only minor changes in design, technology, or operator/maintainer tasks would not require the majority of activities described in this paper but should still be reviewed by HF Personnel. These projects generally result in minimal change to personnel knowledge, skills, selection, training, or system operation and therefore most of these activities would not be appropriate. However, a new, major capital project will in most every case demand HFE participation, since the impact of the new design and the various design alternatives on the Operations and Maintenance personnel are not predetermined.

The questions below are representative of those that can be used to guide project management on the decision as to what level of HFE involvement would be most beneficial to a particular capital project:

- Will the type of personnel involvement or the philosophies related to the operation and/or maintenance of the new facility or equipment differ substantially from what is currently practiced by the company?
- Will the new facility, equipment, instrumentation, etc. introduce new technology or impose new tasks and skill level requirements on the operators and maintainers?
- Is one of the objectives of the new project to optimize staffing levels in the new facility?
- Will the new facility be used by a different user population than is intended in the design standards and specifications?
- Will the facility be designed by a U.S. engineering contractor using U.S. design standards, for use in another country and operated by local or third-country nationals? If so, the design will require some level of cultural calibration, which is a review of the unique cultural requirements of the user nation that differ from U.S. standards.

The answers to these questions and many others will help determine the appropriate level of HFE involvement in the design of the new project.

5.0 THE IMPORTANCE OF THE INVOLVEMENT OF HF PERSONNEL

The selection and assignment of HF Personnel to the design team, together with the relevant HFE design requirements, are crucial to the success of the project's HFE integration effort. The HF Personnel must have the necessary academic credentials and relevant experience in HFE to support the HFE integration process. The integration of HFE requires a particular academic background and expertise. Experience has shown that employing or contracting HF Personnel during a project is a critical factor for successful implementation and integration of HFE (Robertson, 1999; Sworn and Stirling, 1999).

5.1 Experiences Regarding Use of HF Personnel

Studies on two large-scale engineering design projects for topsides in the North Sea by Wulff et. al. (1999), recent experiences with HFE integration in Gulf of Mexico, and other projects indicate that the provision of HFE requirements by themselves are not sufficient to ensure compliance with HFE design principles. The primary findings of these studies were:

- Active HF Personnel integrated in the design organization was critical. Close personal contact appears important for a positive result. HF Personnel functions as a proxy representative of operators and maintainers to ensure that their interests are taken into consideration.
- Neither the personnel responsible for HFE nor the HFE design criteria were well known by project members. It was found that the designers on these projects did not assimilate all the HFE design requirements and transform them into an optimal design. The project documents did not make clear the criteria by which the design was to be optimized nor how to resolve situations where different criteria were in conflict. Due to time and cost constraints, HFE requirements were resisted and in some cases simply not recognized. An interaction between HF Personnel as the owner and the designers as receivers of the new HFE requirements seemed to be more important to the designer's recognition of HFE than the distribution of documents outlining the requirements.
- Design groups are traditionally organized along functional lines, which can make it difficult to develop an overall design with HFE considerations in mind. Workspace design becomes a by-product of the partial designs of these functional groups. Active participation by HF Personnel can help to overcome these organizational barriers. Such participation also creates recognition in different departments of the need for HFE information and an awareness of HFE in general.
- Designers preferred specific HFE requirements to general requirements and recommendations, though providing these requirements did not guarantee their implementation. General requirements have to be supported by procedures to ensure their interpretation in each specific design situation. Due to the sheer amount of documentation, HFE requirements were not always read, and even when read the requirements were not necessarily understood or implemented. In some circumstances requirements were simply not implemented as a consequence of a screening process or a bargaining process where implementation of some requirements won and some lost.

- It appeared that the designer and engineering culture formed by their technical education and previous engineering projects was not conducive to an emphasis on human factors. HFE is only one, and usually not the most important, consideration for design engineers. Schedule and cost are important constraints to the HFE requirements. Since the design is typically developed in parallel by different departments, any requirement that was not known to the designer who made the initial design might imply the need for change, resulting in a design delay. This points to the need to have HF Personnel involved in the design process from the beginning, especially during consideration of the layout.
- Designers were often uncertain how to interpret a general HFE requirement and needed assistance from HF Personnel. If such assistance was not provided, the requirement was not implemented. There was often a conflict between HF and "technical/engineering" requirements. A tight budget and strict time constraints enhanced these conflicts.
- Timing of HFE considerations was also a problem because these considerations were not introduced until the detailed design phase. The study found that the active participation of HF Personnel together with high legitimacy (strong emphasis on HF requirements by regulatory bodies, company and project management) would help to ensure a positive outcome of this conflict or negotiation process.
- Perhaps the most important finding of these studies is the emphasis on engineering design as a trade-off process. Various factors in the design have to be considered. Many times this means that one aspect of the design is made optimal at the expense of another area being made somewhat less then optimal. Often there are many potential choices in the design of a particular aspect. One role of the project engineers is to evaluate the overall effect of these potential choices and determine which provides the best overall solution to the problem both from technical and business standpoints. This process is one of understanding the "trade-offs" involved in the various options.
- It was found that implementation of HFE in such a setting was a matter of negotiation among project members. For HFE to be successfully implemented, a party with strong interests in the HFE aspects of the design is needed. This role is best served by HF Personnel with support from the Operations staff. In addition, the negotiating position of HF Personnel and Operations representatives in engineering design should be strengthened by organizational means.

- HF Personnel had a general quality assurance role and functioned as a resource when there was a need to interpret general requirements into design specifications. It was important to these projects to strengthen the HF Personnel's negotiating position by emphasizing HFE in general company policy documents, by placing HF Personnel high enough in the organizational hierarchy and by enlisting active senior management support. HF Personnel also had the important task of evaluating and to some extent authorizing deviations.

In summary, both recent experience on Gulf of Mexico deepwater projects and the studies by Wulff et. al. (1999) point out the need for HF Personnel involvement from the conceptual design phase through the project's commissioning and start-up.

5.2 Responsibility for Execution of HFE

The HFEP or HF integration strategy comprises certain typical HFE activities that need to be performed at pre-determined stages throughout the various phases of a project. These HFE tasks/activities take place concurrently with engineering activities throughout the project's execution. Some HFE activities are dependent on engineering decisions and in other cases outputs from HFE tasks/activities influence engineering decisions. HFE and engineering activities are therefore interdependent.

Responsibilities for performing HFE activities are normally assigned to one of three individuals or groups. First, there is the HFE Champion within the company project management team who will be assigned HFE approval authority on most if not all matters concerning HFE. The HFE Champion must be assisted by HF Personnel (as defined above) to support the HFE Champion on technical and other matters as needed. These two individuals or groups will represent the company in all matters relating to HFE on the project. They will be responsible for all HFE activities performed prior to the award of the contract as well as activities identified as being outside the scope of work of the contractor's HF Personnel. These two company positions can be combined if a person with the relevant HFE training and experience can be identified.

The third group of individuals are those HF Personnel, Health and Safety and other personnel within the company, contractor, and occasionally vendor, organizations who will be responsible for all HFE related activities to be performed as required by the Project Specification during all project phases. More responsibility and activities assigned to the company HF Personnel would necessarily result in fewer activities being performed by the contractor's HF Personnel, and vice versa. Past experience has shown that it is more important and beneficial to the end product, if the majority of the HFE activities are taken up by HF Personnel representing the company rather than the contractor. Regardless, HF Personnel, whether company or contract, must be viewed and utilized as an integral part of the design team and have the project management's commitment and support for their activities. These critical success factors for an HFE integration strategy are discussed in Section 2.0.

Examples of specific responsibilities for some of the HFE activities generally performed are provided in the responsibility matrix included in the Sample HFEP. The responsibilities and titles used may vary depending on the contracting strategy as well as what phase of the life cycle the project is in. The contracting strategy will determine who is responsible for the execution of HF activities, specified as the company HF Personnel, contractor HF Personnel or possibly both. The project life cycle phase will determine whether the HFE Champion role is taken up by the Engineering, Construction, Commissioning or Offshore Installation Manager.

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Acknowledgements

This white paper was developed in conjunction with authors of a paper (McCafferty et. al.) presented at the 2002 Offshore Technology Conference (Houston, Texas, May 6-9, 2002) entitled Human Factors Engineering Implementation Strategy: A Generic Approach.

Appendix A - Additional References

Reference	Title
33 CFR	Navigation and Navigable Waters
33 CFR 127	Training requirements - General
33 CFR 155	Training requirements - Navigable waters
33 CFR 95	Operating a vessel while intoxicated
46 CFR	Shipping
46 CFR 10	Licensing of maritime personnel
46 CFR 16	Periodic testing for drugs
46 CFR 5	Maritime Investigation requirements - personnel/drugs/alcohol
ABS	Guidance Notes on the Application of Ergonomics to Marine Systems, American Bureau of Shipping
ANSI/ IESNA RP-1	American National Standard Practice for Office Lighting
ANSI/HFS100-88	American national standard for human factors engineering of visual display terminal workstations
ANSI-S3.2-89	Method for measuring the intelligibility of speech over communication systems
ARI 575-87	Method of measuring machinery sound within an equipment space
ASHRAE 55-66	Comfort standard
ASHRAE 62-1989	Ventilation for Acceptable Indoor Climate
ASTM F1166	Standard Practice for Human Engineering Requirements for Ships and Maritime Systems, Equipment, and Facilities
ASTM F1337	Standard Practice for Human Engineering Program Requirements for Ships and Maritime Systems, Equipment, and Facilities
BS 4884 Part 1	Technical manuals, Specification for presentation of essential information
BS 4884 Part 2	Technical manuals, Guide to content
BS 4884 Part 3	Technical manuals, Guide to presentation
BS 4899 Part 1	Users requirements for technical manuals – Content
BS 4899 Part 2	Users requirements for technical manuals - Presentation
BS 6841	Measurement and evaluation of human exposure to whole body mechanical vibration and repeated shock
BS 95/201899	Lighting Applications - Emergency lighting
Defense Standard 00-25: Parts 1-13	Human factors for the designers of equipment. Directorate of Standardization: Glasgow, Scotland. United Kingdom Ministry of Defense (1988)
DOD-HDBK-743A	Anthropometry of U.S. Military personnel (metric)

Reference	Title
DOT/FAA/CT-96-1	Human Factors Design Guide for Acquisition of Commercial-Off-the-Shelf Subsystems, Non-Developmental Items, and Developmental Systems—Final Report and Guide
EN 292-1	Safety of Machinery - Basic concepts, general principles for design - Part 1- Basic terminology, methodology
EN 292-2	Safety of Machinery - Basic concepts, general principles for design - Part 2 - Technical principles and specifications
EN 349	Minimum gaps to avoid crushing parts of the human body
EN 563	Safety of Machinery - Temperatures of Touchable Surfaces - Ergonomics Data to establish TLV’s for hot surfaces
EN 614-1	Safety of Machinery - Ergonomic design principles Part 1 - Terminology and general principles
EN 894-1	Safety of Machinery - Ergonomic requirements for the design of displays and Control Actuators. Part 1 General principles for human interactions with displays and control actuators
FAA	Human Factors Design Guide
IACS	Unified Interpretation SC82 Protection against noise, 1993
IACS	Requirements concerning NAVIGATION. Unified requirements for One Man Bridge Operated (OMBO) Ships. International Association of Classification Societies. 1992
IACS N1	Requirements concerning Navigation
IEC 225	Octave, half-octave and third-octave band filters intended for the analysis of sound and vibration
IEEE85-72	Airborne sound measurements on rotating electric machinery
IESNA RP-12-97	Illuminating Engineering Society of North America, Recommended Practice for Marine Lighting
ILO	International data on anthropometry. Occupational Safety and Health Series: No. 65, (1990)
ILO Convention 133	Convention concerning crew accommodation on board ship (supplementary provisions)
ILO Convention 147	Convention concerning minimum accommodation standards in merchant ships
ILO Convention 155	Recommendations concerning the improvement of accommodation standards in merchant ships
ILO Convention 92	Convention concerning crew accommodation on board ship (Revised 1949)
IMO	International Safety Management Code

Reference	Title
IMO 343 (IX), Agenda item 7	Recommendation on methods of measuring noise levels at listening posts
IMO A.19(830)	Code on Alarms and Indicators
IMO A.468(XII)	Code on Noise Levels on Board Ships
IMO DE 38/20/1	Role of the Human Element in Maritime Casualties - Engine Room Design and Arrangements
IMO DE 38/20/2	Role of the Human Element in Maritime Casualties - Guidelines for the on board use and application of computers
IMO DE 40/WP.5	Draft MSC Circular, Guidelines for engine room layout, design and arrangement
IMO NAV 43/6	Ergonomic Criteria for Bridge Equipment and Layout
IMO NAV 45/6	Ergonomic criteria for bridge equipment and layout
IMO RES. A.686 (17)	Code on Alarms and Indicators
IMO RES. A.708-17	Navigation Bridge Visibility and Functions
ISO 10075	Deals with ergo principles related to mental workload
ISO 10551	Ergonomics of the thermal environment—Assessment of the influence of the thermal environment using subjective judgment scales
ISO 11064-1	The Ergonomic Design of Control Centers Part 1 Principles for the design of Control Centers
ISO 11064-2	The Ergonomic Design of Control Centers Part 2 Principles of Control Suite Arrangement
ISO 11064-3	The Ergonomic Design of Control Centers Part 3 Control Room
ISO 11064-4	The Ergonomic Design of Control Centers Part 4 Workstation and Layout Dimensions
ISO 11064-5	The Ergonomic Design of Control Centers Part 5 Displays and Controls
ISO 11064-6	The Ergonomic Design of Control Centers Part 6 Environmental Requirements for Control Rooms
ISO 11064-7	The Ergonomic Design of Control Centers Part 7 Principles for the Evaluation of Control Centers
ISO 11064-8	The Ergonomic Design of Control Centers Part 8 Ergonomic Requirements for Specific Applications
ISO 11399	Ergonomics of the thermal environment—Principles and application of relevant International Standards
ISO 13731	ISO/CD Ergonomics of the thermal environment - vocabulary
ISO 13732	ISO/NP Contact with hot, moderate, and cold surfaces
ISO 14612	Ship's bridge layout and associated equipment - Requirements and Guidelines

Reference	Title
ISO 14726-1.	Ship and marine technology—Identification colors for the contents of piping systems—Part 1: Main colors and media
ISO 1999	Acoustics -- Determination of occupational noise exposure and estimation of noise-induced hearing impairment
ISO 2041	Vibration and shock - vocabulary
ISO 2631	Guide for the evaluation of human exposure to whole-body vibration
ISO 2923	Acoustics - Measurement of noise on board vessels
ISO 4867	Code for the measurement and reporting of shipboard vibration data
ISO 4868	Code for the measurement and reporting of local vibration data of ship structures and equipment
ISO 6385	BSI/ISO standard - Ergonomic Principles in the design of Work Systems
ISO 6954	Mechanical vibration and shock - Guidelines for the overall evaluation of vibration in merchant ships
ISO 717/1	Acoustics - Rating of sound insulation in buildings and of building elements: Part 1: Airborne sound insulation in buildings and interior elements
ISO 717/1	Acoustics - Rating of sound insulation in buildings and of building elements: Part 2: Impact sound insulation
ISO 7243	Hot Environments - Estimation of the Heat Stress on Working Man, based on the WBGT Index
ISO 7250	Basic Human Body Measurements for Technological Design
ISO 7547	Shipbuilding - Air conditioning and ventilation of accommodation spaces on board ships - Design conditions and basis of calculations
ISO 7726	Thermal environments - Instruments and methods for measuring physical quantities
ISO 7730	Moderate Thermal Environments - Determination of the PMV (Predicted Mean Vote) and PPD (predicted percentage dissatisfied) Indices and Specification of the Conditions for Thermal Comfort
ISO 8041	Human response to vibration - Measuring Instrumentation
ISO 8468 (E)	Ship's Bridge layout and Associated Equipment - Requirements and Guidelines
ISO 8861	Shipbuilding—Engine-room ventilation in diesel engine ships—Design requirements and basis of calculations
ISO 8862	Shipbuilding - Air-conditioning and ventilation of machinery control rooms on board ships - Design conditions and basis for calculations
ISO 8864	Shipbuilding - Air-conditioning and ventilation of wheelhouse on board ships - Design conditions and basis for calculations

Reference	Title
ISO 9241-1	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 1 A General Introduction
ISO 9241-10	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 10 - Dialog Principles
ISO 9241-11	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 11 - Guidance of Usability Specification and Measures
ISO 9241-13	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 13 User Guidance
ISO 9241-14	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 14 Menu dialogs
ISO 9241-2	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 2 Guidance and Task Requirements
ISO 9241-3	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 3 - Visual Display Requirements
ISO 9241-4	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 4 - Keyboard Requirements
ISO 9241-5	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 5 - Workstation Layout and Postural Requirements
ISO 9241-6	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 6 - Environmental Considerations
ISO 9241-7	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 7 - Display Requirements with Reflections
ISO 9241-8	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 8 - Requirements for Display Colors
ISO 9241-9	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 9 - Requirements for non-keyboard input devices
ISO DIS 13407	Human-Centered Design Processes For Interactive Systems
ISO/DIS 9241-12	Ergonomic Requirements for Office Work with Visual Display Terminals (VDT's) Part 12 - Presentation of Information
MIL-HDBK-1908B	Definitions of human factors terms
MIL-HDBK-46855A	Human engineering program process and procedures
MIL-HDBK-759C	Human engineering design guidelines
MIL-STD-1472F	Human engineering design guidelines
MIL-STD-1474D	Noise limits

Reference	Title
MIL-STD-740/1	Airborne sound measurements and acceptance criteria of shipboard equipment
NASA 1024 Vol. 1-3.	Anthropometric source books, 1978, National Aeronautics and Space Administration
NASA-STD-3000	Man system integration standards, July 1995, National Aeronautics and Space Administration
NORSOK S-002	Working Environment
NORSOK C-CR-002	Common Requirements - Architectural Components and Equipment
OSHA 3123	Ergonomics Program Management Guidelines for Meatpacking Plants. Occupational Health and Safety Administration publication (1991)
Reference Book	Bailey, R.W. (1989). *Human Performance Engineering,* 2nd Edition. Englewood Cliffs, NJ: Prentice Hall. ISBN 0-13-445180-5
Reference Book	*Ergonomic Design for People at Work, Volume 1.* Eastman Kodak Company (1983). New York: Van Norstrand Reinhold. ISBN 0-534-97962-9 (v. 1)
Reference Book	*Ergonomic Design for People at Work, Volume 2.* Eastman Kodak Company (1986). New York, Van Norstrand Reinhold. ISBN 0-442-22103-7 (v. 2)
Reference Book	Kroemer, K.H.E., Grandjean, E. (1997). Fitting the task to the human, 5th Edition. London: Taylor & Francis. ISBN 0-7484-0664-6 (cased), or -0665-4 (paperback)
Reference Book	Meister, D. (1989). *Conceptual aspects of human factors*. Baltimore: The Johns Hopkins University Press
Reference Book	Noro, K., Imada, A.S. (1991). *Participatory Ergonomics.* London: Taylor & Francis
Reference Book	Pheasant, S. (1987). Ergonomics: Standards and guidelines for designers. British Standards Institute, (PP 7317:1987) ISBN 0-580-15391-6
Reference Book	Salvendy, G. (ed.) (1997) Handbook of human factors and ergonomics. John Wiley & Sons, Inc.: New York, NY
Reference Book	Sanders, M., McCormick, E. J. (1993). Human factors in engineering and design. 7th Edition. New York, McGraw-Hill
Reference Book	Van Cott, H.P., Kinkade, R.G. (eds.) (1992) Human engineering guide to equipment design. McGraw-Hill Book Company: New York, NY
Reference Book	Woodson, W., Tillman, B., Tillman, P. (1981) Human engineering design handbook. McGraw Hill Publishing: New York, NY
SAE-HIR1622A	Noise control in fluid power systems of marine Vehicles
SAE-J1050-94	Describing and measuring the field of view

Reference	Title
SAE-J209-71R87	Design and location for construction and industrial equipment, instrument face
SAE-J833-89	Human physical dimensions
SAE-J88-95	Machines, off-road work, -exterior, sound measurement
SAE-J899-88	Seat dimensions for work machines, off-road self-propelled, operator's
SOLAS II-1/36	Protection against noise
STCW 95	Standards, Training, Certification for Watch Standing, 1995
VDI 2056	Criteria for assessing mechanical vibrations of machines, Verein Deutschen Ingenieure

Appendix B - Sample Policy Statement

Vision. To improve overall system performance and reliability, by optimizing personnel performance, health, and safety through effectively integrating Human Factors Engineering principles into a project lifecycle.

Mission. To manage and integrate Human Factors Engineering through all the relevant phases of the project lifecycle in order to minimize the potential for human error and optimize operability and maintainability during facility operation.

Objectives. Objectives for HFE implementation include:

- Creating awareness of HFE at all levels of a project management team.
- Commitment for demonstrating the economic and health, safety, and environmental (HSE) benefits from applying HFE.
- Ensuring management and line responsibility exists for HFE implementation within a project team
- Ensuring HFE activities and tasks are effectively integrated into the project schedule for all major project phases.
- Establishing accountability for implementation of HFE within the project team.

Appendix C - Sample Project Human Factors Engineering Plan

HUMAN FACTORS ENGINEERING PLAN (HFEP)

1.0 Introduction

1.1 Overview

The COMPANY's commitment to Health, Safety and Environmental (HSE) performance is communicated through its mission statement. The mission statement commits the company to work towards the goal of "minimizing accidents, and to provide a safe and healthy work environment to its employees."

Hazard management will ensure that all HSE risks, appropriate to each phase of project activities, are satisfactorily addressed. One of the areas of hazard management, as addressed in the document "Hazard Management Design Philosophy" is Human Factors Engineering. The potential for human error is reduced through the application of Human Factors Engineering (HFE) design principles during the engineering phase of the project. The integration of HFE with the other engineering disciplines ensures that designs are created that effectively match the best of human and machine capabilities to create operational hardware and software which reduces the potential for human error, increases overall system availability and people satisfaction.

1.2 Scope

The purpose of this document is to define the HFE scope of work(activities), organizational structure, responsibilities and implementation plan for those responsible, within the project organization. These persons have been tasked with ensuring that HFE design requirements and principles are integrated during the detailed design and procurement, construction, hook-up and commissioning phases of this project.

The overall HFE design objectives, which also apply to vendor-supplied equipment, can be summarized as follows:

Operability – Ensure that the layout of equipment, including vendor supplied skid mounted packages, allows for easy access during the operation and maintenance of the units under all normal, upset/emergency and weather conditions by the full range of potential employees (i.e. 5^{th} percentile female to the 95^{th} percentile male, with personal protective equipment, cold weather clothing). The operability of the equipment also ensures the usability of display and control design including DCS console screens layouts and local control panels. This would mean that the placement and orientation of all controls and displays/instruments are appropriate to ensure safe and effective viewing, reach, and operation by COMPANY personnel.

Maintainability – Ensure the efficient and safe movement of equipment requiring maintenance without removal of other items such as piping, motors, etc. (This includes the provision of adequate space and laydown areas for the anticipated activities. Consideration should also be given to the provision and configuration of doors and access hatches.) Access/Egress – Ensure that all areas of the facility and equipment can be accessed and evacuated safely under normal, adverse weather and emergency conditions.

Manual materials handling – Ensure requirements for manual lifting, pulling, pushing, and carrying of equipment, with respect for the biomechanical and physiological capabilities and limitations of the personnel are included during design. Associated needs include the availability of mechanical lifting aids for assisted lifting and appropriate storage or placement of lifting aids for safe reach and effective operation.

Communication/Labeling – Ensure the clear communication of information and equipment identification, including effective viewing, reading, and understanding of instructions, signs, labels, operations and maintenance manuals.

Environmental – Ensure that environmental requirements regarding noise, lighting, vibration, climatic conditions and proximity to hot, cold, hazardous and contaminated equipment or areas have been addressed.

Habitability – Ensure the provision of acceptable personnel accommodations and recreational facilities, and minimize psycho-physiological stress effects of workload, fatigue, and social interaction.

Health and Safety – Ensure the provision of adequate medical facilities, non-restrictive personal life support and protection equipment.

2.0 PROJECT HFE DOCUMENTS

The detailed HFE design requirements for this project are referenced in the following documents:

- Human Factors Engineering Requirements for Workplaces
- Human Factors Engineering Requirements for Location and Orientation of Valves
- Human Factors Engineering Requirements for Controls, Displays, Alarms & User Panels/Consoles
- Human Factors Engineering Requirements for Labels and Signs
- Human Factors Engineering Requirements for Ramps, Stairs, Vertical Ladders, Work Platforms, Walkways and Railings
- Human Factors Engineering Requirements for Computer Displays

Other Related Project Specifications:

- Human-Machine Interface Design Guideline

3.0 ORGANIZATION AND RESPONSIBILITIES

Some of the key ingredients for the successful integration of HFE, during the various phases of a capital project's life cycle, are management commitment and the support of people at all levels of the project organization. An integration strategy is required which will establish line responsibility for HFE. This can best be achieved by introducing Human Factors into the existing project management systems with the prime objective of ensuring that HFE is executed effectively and efficiently at every stage of the project life cycle.

In order to ensure that HFE design requirements are addressed in time and integrated throughout the detailed engineering design and procurement, construction, hook-up and commissioning phases of a development project, the responsibility for implementation has been assigned to a number of people within the project organization. The organizational structure is shown in Figure 1 below.

The overall responsibility for ensuring that HFE design requirements are integrated during the detail design engineering and procurement is with the Engineering Manager. He will report to the Project Manager on all matters relating to HFE. HFE Personnel support, to ensure technical integrity and quality assurance, will be provided by a HFE Personnel. The HF Personnel with the assistance of other HF Personnel assigned by the Engineering Manager on an as needed basis, will be responsible for executing the HFE tasks identified in Section 4: HFE Scope of Work, and for providing Personnel support to the various disciplines and interpreting HFE requirements. The role and responsibility of HF Personnel in the execution of the HFE Scope of Work is summarized in the Responsibility Matrix provided in Appendix D. The functional disciplines will be responsible for day to day detail design activities and procurement and to ensure compliance with the appropriate HFE design requirements as referenced in Section 2: Project HFE Documents. A schedule for the execution of the HFE tasks/activities is included in Appendix E.

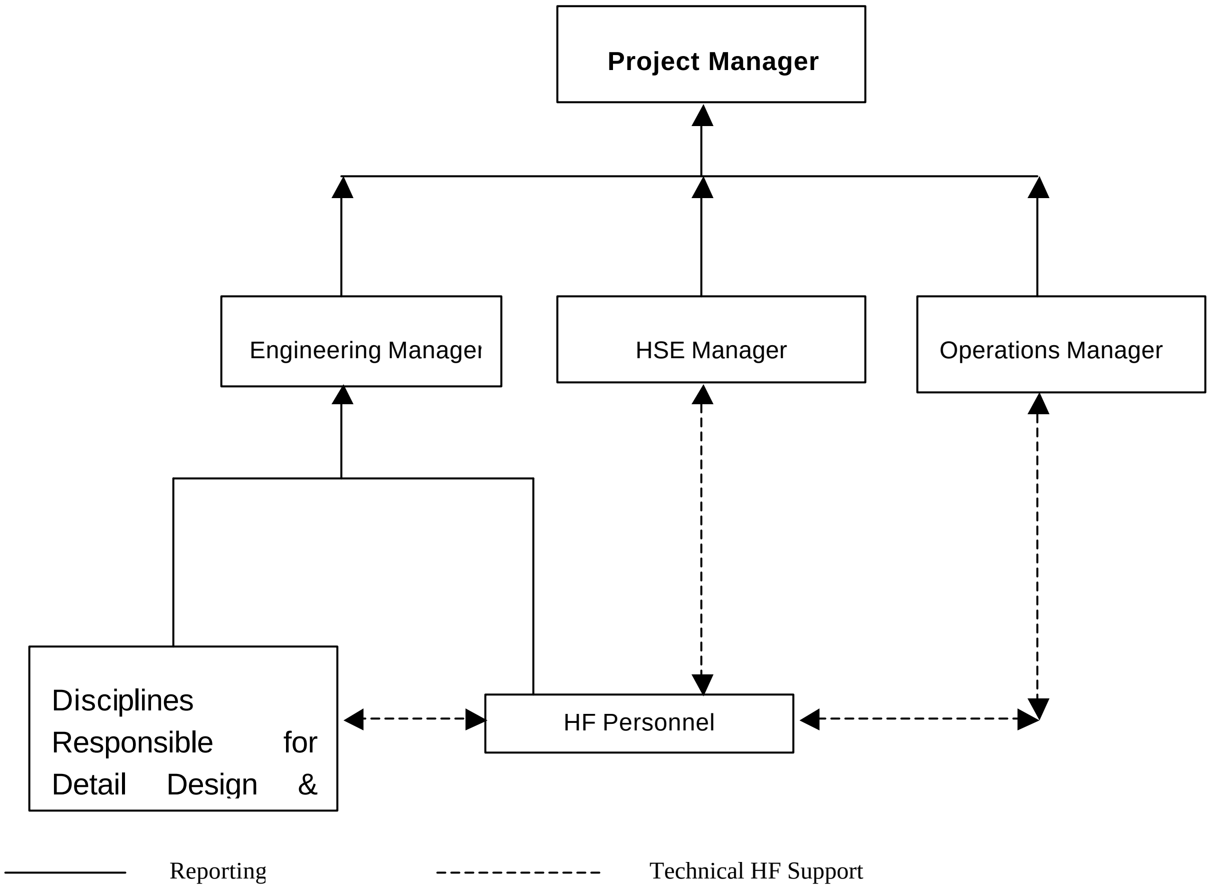

Figure 1: HFE organizational structure during detail design and procurement phases

4.0 HFE Scope of Work

A summary of the main HFE task activities to be performed by those responsible is as follows:

4.1 Conduct a Front End Human Factors Engineering Analysis (FEHFEA):

The purpose of this task analysis of future operations, maintenance activities, and of lessons learned on similar existing facilities, if applicable, is to identify potential problems in the design of the human-machine-environment interface and to ensure that these are addressed during the detailed engineering design.

4.2 Determine HFE Priorities:

Review deliverables (drawings and documents) and equipment lists to determine HFE review priorities and to identify and prioritize vendor packages, equipment, areas or procedures requiring HFE input or attention. Prioritization will be based on lessons learned from previous projects, equipment criticality, the potential for and consequence of human error, and the expected maintenance and Human-Machine interface (HMI) requirements. It is envisioned that only specific vendor packages, where the vendor is responsible for the package design, would be included.

4.3 Training:

Provide awareness training to project management and more detailed training to the project engineering and design team.

4.4 HFE Design Guidelines and Checklists:

Existing COMPANY HFE design guidelines will be utilized on the Generic Example Project. Additional HFE checklists as applicable for incorporation by designers and for inclusion in Request for Quotation's (RFQs) for previously identified vendor packages will be developed

4.5 Document all HFE Design Recommendations:

Document all HFE design recommendations and develop a database for keeping track of recommendations to allow for follow-up and closure as well as for reporting purposes to Project Management.

4.6 Valve Criticality Analysis (VCA)

Develop a set of criteria regarding location and means of access to be used when classifying valves with input from Engineering and Operations. These criteria will then be incorporated into the design and validated during subsequent review activities.

4.7 Review Engineering Drawings and Design Documents:

Generate a list of drawings and documents requiring HFE review based on the prioritization mentioned in Section 4.2. Review drawings and documents to develop recommendations for HFE improvements. Document all HFE design recommendations in database for tracking.

4.8 Evaluate Vendor Bid Packages:

For the specific vendor packages identified in 4.2, as requiring detailed HFE review, evaluate the vendor bid submittals for inclusion of the criteria contained in the HFE checklists and provide any HFE bid clarification required. Vendor designs for the selected packages will be reviewed to identify opportunities for HFE improvements with respect to design, packaging, operations, and maintenance. All work on the vendor packages would be under the direction of the responsible package engineer.

Other vendor packages will be reviewed for HFE content as part of the bid evaluation and designs will be reviewed by engineering personnel who have received HFE training.

4.9 Formal Safety Assessments (FSA):

HFE will be a component in the various FSAs conducted on the project. HF Personnel will participate in these meetings as needed and address specific recommendations from the reviews.

4.10 HFE Input to special design studies:

Participate in design studies that address HFE concerns, for example, materials handling and maintenance access study, dropped object study, Emergency Evacuation and Rescue Study (EERS), acoustical study, long term inspection and maintenance requirements or any other study at the request of Engineering or Operations.

4.11 3D Model Reviews:

HF Personnel will attend and provide input at the various 3D model reviews. All HFE action items identified will be recorded in the minutes of the meeting for action and tracking until close out.

At the 30% model review, the HFE goal is to verify that there will be sufficient clearances and unobstructed paths for movement of people and equipment, as well as accessibility to critical items and valves. Additional HFE goals are to review the sufficiency of work areas for both operations and maintenance and sufficient and logical pathways and egresses for EER.

At the 60% model review, the HFE goals include verification of sufficient and proper access at elevations for operations and maintenance, further clarification on EER routes, preliminary materials handling review, evaluation of personal safety systems, and consideration of human interfaces.

The 90% model review allows for verification of the previous recommendations and further consideration of accessibility, operability, mobility and maintainability issues.

4.12 Design of Accommodation Facilities:

Identify HFE criteria for habitability of the accommodations facility (Living Quarters). Review engineering and layout drawings associated with the accommodations facility for compliance with habitability criteria and provide recommendations as needed.

4.13 Design of Control Room and MCC Buildings:

Work with Operations to identify task requirements and functions to be performed in the control room and MCC buildings. Participate in developing design layouts and review final design, alarm handling and equipment selected for HFE concerns.

4.14 Design of Fire & Gas, General Platform Alarm and Paging System:

Review the layout of panels, as well as the location of visual and audio alarms for compliance to HFE design guidelines.

4.15 Labeling:

Work with engineering to implement project wide labeling design guidelines. Review labeling,

instructions, warning signs, and pipe coding systems for compliance with labeling design guidelines.

4.16 Construction Team HFE Training:

Conduct awareness seminars and special training sessions to the construction field staff (Company and Contractors) to develop the general awareness for HFE and ergonomics.

4.17 Conduct On-site Visits to Contractor Fabrication Facilities:

Participate as part of Safety Review Team in selected contractor site visits. These visits will verify that the HFE recommendations during the engineering phase have been implemented as per design. Provide HFE Personnel support during the installation of “Field Installed” equipment to ensure the application of project HFE philosophies.

4.18 Development/Review of Training Devices and Materials:

Provide assistance to Operations in the development and review of training material, as needed.

4.19 Review Project O & M Documentation:

Review documents, job aids and Operations and Maintenance procedures and instructional manuals to make certain they meet HFE usability design principles.

4.20 HFE Report:

Prepare HFE reports for submission to Project Management at scheduled intervals. Reports should provide the status of HFE activities and recommendations made.

4.21 Installation, Hook-up and Commissioning:

Participate in the installation, hook-up, commissioning and start-up of the facility to observe those activities that will allow for the verification of the tasks and operational and maintenance procedures that were developed. The presence of HF Personnel during this time will allow HF to be considered in the correction of problems identified, provide an opportunity for the generation of lessons learned from the HF Personnel's experiences and provide a better understanding of the practical methods used for performing common operations and maintenance tasks and procedures.

4.22 Operation:

Participate in the following activities as part of the API requirements for tracking operability in the first year:

- Conduct operability assessment before the end of the first year of operation.
- Obtain operator feedback via written and personal interviews regarding HFE successes and failures relative to operability and maintainability
- Monitor accident/incident reports for the identification of HFE design deficiencies
- Develop a lessons learned file or database.

5.0 Implementation process

The implementation process will use the HFE design requirements as provided in the documents referenced in Section 2, as the basis for the design and the procurement of vendor supplied equipment or packages/skids. These requirements will be supplemented by HFE design information and checklists developed by HF Personnel to provide more detailed design guidance to design engineers and vendors where applicable.

In case of any non-compliance with an HFE design requirement or issue raised which cannot be resolved within the discipline or with a specific Vendor, it will be referred to the Engineering Manager. If resolved it will be executed and the result will be recorded in the HFE Tracking Database for close out and sign off by the HFE Champion for that stage of the project life cycle. The HFE Champion may be the Engineering Manager for the Detailed Design Phase, Construction Manager for the Construction Phase, Commissioning Manager for the Commissioning Phase and the OIM after start-up. If the issue is deemed a safety concern, it will be entered into the Hazard Management Process as defined for the project for resolution and execution. The result will be recorded in the database for close out and sign off.

Appendix D - Responsibility Matrix

Responsibility Matrix							
	Description of HFE Activity	HFE Champion	HF Personnel		Other Disciplines (Eng., Operations, HSE)		
		Accountable	Responsible	Review & Comment	Responsible	Technical Support	Review & Comment
1	Front End HFE analysis	X	X			X	X
2	Determine HFE priorities	X	X			X	X
3	HFE training to project design team	X	X				
4	HFE design guidelines and checklists	X	X			X	X
5	Document all HFE design recommendations	X	X				
6	Valve criticality analysis	X		X	X		
7	HFE review of engineering drawings and design documents	X	X			X	X
8	HFE evaluation of Vendor bid packages	X	X			X	X
9	Formal Safety Assessments (FSA)	X		X	X		
10	HFE input to special design studies	X		X	X		
11	3D Model reviews	X		X	X		
12	Design of accommodation facilities	X		X	X		
13	Design of control room and MCC buildings	X		X	X		
14	Design of fire & gas, general platform alarm, and paging system	X		X	X		
15	Labeling program	X		X	X		

Responsibility Matrix							
	Description of HFE Activity	**HFE Champion**	**HF Personnel**		**Other Disciplines (Eng., Operations, HSE)**		
		Accountable	Responsible	Review & Comment	Responsible	Technical Support	Review & Comment
16	HFE training to construction team	**X**	**X**				
17	HFE review during on-site visits to contractor fabrication facilities	**X**	**X***			**X**	**X**
18	HFE assistance during development of Training devices and material	**X**		**X***	**X**		
19	HFE review of project O & M documentation	**X**		**X***	**X**		
20	Generate HFE status reports	**X**	**X**				**X**
21	HFE support during installation, hook-up and commissioning	**X**		**X***	**X**		
22	HFE support during Operational Assessment	**X**		**X***	**X**		

Appendix E - Schedule of HFE Tasks/Activities

Schedule of HFE Activities during Concept, Design, Construction, and Operation *					
HFE Activity		Project Life Cycle Phase			
		Concept	Detailed Design	Construction to Commissioning	Operation
1	Include HFE Requirements in Project Specification(s)				
2	Develop Human Factors Engineering Plan				
3	HFE input and review during concept design studies				
4	Front End HFE analysis				
5	Determine HFE priorities				
6	HFE training to project design team				
7	HFE design guidelines and checklists				
8	Document all HFE design recommendations				
9	Valve criticality analysis				
10	HFE review of engineering drawings and design documents				
11	HFE evaluation of Vendor bid packages				
12	Formal Safety Assessments (FSA)				
13	HFE input to special design studies				
14	3D Model reviews				
15	Design of accommodation facilities				
16	Design of control room and MCC buildings				
17	Design of fire & gas, general platform alarm, & paging system				
18	Labeling program				
19	HFE training to construction team				
20	HFE review during on-site visits to contractor fabrication facilities				
21	HFE assistance during development of Training devices and material				

Schedule of HFE Activities during Concept, Design, Construction, and Operation *

HFE Activity		Project Life Cycle Phase			
		Concept	Detailed Design	Construction to Commissioning	Operation
22	HFE review of project O & M documentation				
23	Generate HFE status reports				
24	HFE support during installation, hook-up and Commissioning				
25	HFE support during Operational Assessment				

* = Shaded area indicates when the HFE activity is performed.

Appendix F - Equipment and Systems Listing

System	HFE Priority	HFE Areas of Concern
Safety Systems Related Equipment		
Temporary refuge	High	Physical space, personnel and equipment survivability, ease of access in an emergency, location of refuge in relation to work stations, personnel movement flow during , evacuation, temporary increases in POB
Muster area and embarkation station	High	Physical space, personnel and equipment survivability, location in relation to temporary refuge and work stations, access to life preservers, marshalling of personnel, temporary increases in POB
Fire and Gas detection	High	Primary (and secondary if used) control and monitoring panel design, layout and location and computer display design
Emergency shutdown system	High	Local and central control Station, design, location, orientation, labeling and accessibility
Fire Fighting Systems	High	Location of equipment, control and display design and layout, adequate access for operability and maintainability (equipment removal and replacement), location of fire water pumps
Fire-main	Medium	Adequate access for operability and maintainability of isolation valves, labeling of main sections for easy identification during emergencies
Fire Sprinklers	Medium	Labeling and maintainability concerns
Passive Fire Protection	Medium	Adequate access for inspection and maintenance
Lifeboats and Evacuation Equipment	High	Confirmation that lifeboats will hold the rated number of offshore personnel, launch station control design, provision of adequate access for maintainability and operability, location of lifeboats and other evacuation equipment, route marking, equipment storage, stretcher access and training
Lifesaving and Escape Devices	Medium	Equipment storage and location, size, fit of lifesaving devices, equipment marking/labeling/instructions
Collision Avoidance Radar	High	Location and orientation of CAR in Control Room, CAR display and control design, control room interface, ease of access to CAR antenna for maintenance

System	HFE Priority	HFE Areas of Concern
Emergency generator	High	Generator skid placement and arrangement, local control panel design and layout, control room interface, ease of access to and around generator for maintenance and repair
Emergency switchboard	Medium	Color coding, indicator lights, equipment removal and replacement
UPS system batteries, inverter, and distribution	High	Display design, control design, lifting, devices to assist in equipment lifting/movement
Containment systems (liquid and gaseous hydrocarbons)	High	Adequate access for maintainability and operability, control room interface, control panel design, valve access, evacuation issues for injured personnel
Pneumatic supply system	Medium	Adequate access for maintainability and operability, valve access
Ventilation systems	Medium	Ventilation rate, breathable air volumes, air velocity, thermal comfort, humidity
Communication Related Equipment		
Navigational aids (e.g., foghorns, beacons, etc.)	Medium	Ease of access for maintenance (especially replacement of beacon lights)
Emergency Hotline telephone	Medium	Appropriate location and standardization of any audible alarms and/or messages
Radio communications – general	Medium	Standardize radio frequencies (e.g. one for crane, one for operations, etc.)
Telephone – VHF/UHF	Medium	Location with respect to noise and usage requirements
Intercommunication	Medium	Procedures, equipment, location of personnel
Structure Related		
Hull/Structure (including watertight devices)	Medium	Ease of access to voids and tanks for inspection or maintenance, manway and hatch dimensions, evacuation issues for injured personnel, identification of tanks and voids
Ballast tanks and control system	High	Local and Control Room control panel design, layout and orientation, adequate access for maintainability and operability, EER issues for injured personnel, proper labeling of all components
Towing devices	Low	Arrangement and placement of equipment for operability and maintenance
Mooring systems	Medium	Arrangement and placement of equipment for operability and maintenance

System	HFE Priority	HFE Areas of Concern
Crude oil cargo and slop tanks	Medium	Adequate access for maintainability and operability, design, orientation and location of transfer manifolds and/or control consoles, evacuation issues for injured personnel
Tanks hydraulic system	Medium	Equipment removal and replacement, filter removal and replacement, adequate access for maintainability and operability
Cargo tank washing systems	Low	Arrangement and placement of equipment for operability and maintenance
Inert gas	Medium	Local and Control Room control panel design layout, orientation, control/display design, training and sign posting
Environment monitoring system	Low	Design and layout of system controls, displays and the design control panel, computer screens
Production/Offloading Related		
Subsea pipelines risers and umbilicals	Low	Arrangement and placement of equipment for operability and maintenance
Subsea controls system and HPU	High	HPU skid layout and arrangement, local control panel design and layout, location of skid in relation to other equipment, adequate access for maintainability and operability, lifting issues associated with hydraulic fluid cylinders (HPU)
Wellstream handling and testing, wellheads and flowlines	Medium	Control panel design and layout, display design, valve access and maintenance
Oil stabilization and treatment	Medium	Skid placement and arrangement, control room interface, control panel design, valve access
Produced water and sand treatment	Medium	Skid placement and arrangement, control room interface, control panel design, valve access
Water injection	Medium	Skid placement and arrangement, control room interface, control panel design, valve access
Gas compression and distribution	High	Local control panel design, orientation and layout, adequate access for maintainability and operability, control room interface, skid placement and arrangement, tube bundle or filter removal, equipment removal and replacement, mechanical handling devices, manway size and location, noise and thermal protection, lighting
Gas dehydration and treatment		
Gas injection		
Glycol regeneration		
Fuel gas		
Heat Exchangers		

System	HFE Priority	HFE Areas of Concern
Separators		
Pig launchers/receivers	High	Design of Launcher/Receiver barrel, access for loading pigs, safety warnings, interlocks, operating instructions
Flare relief and blow-down	High	Access to Flare Tip for inspection, maintenance and Tip removal and replacement, Heat Flux (thermal radiation) exposure to personnel
Metering system	Medium	Local display design and layout, control room interface, graphical user interface (computer screen design), ease of access for loading meter prover ball
Offloading	Medium	Hose storage and lifting, ease of access to valves, offloading control console design, layout, location and orientation
Power and Utility Systems Related		
Instrument air compressor, air receivers, dryers, and distribution	Medium	Skid placement and arrangement, local control panel design and layout, control room interface
Main power generation and distribution	High	Skid placement and arrangement, ease of equipment removal and replacement, local control panel design and layout, control room interface
General lighting	Low	Drawing review for fixture arrangement and placement
Sewage and water disposal	Medium	Skid placement, layout, and arrangement, local and Control Room control panel design, orientation and layout, ease of maintenance (especially on sewage treatment system
Potable water	Low	Control panel design and layout, labeling
Seawater pumping and treatment	Low	Skid placement and arrangement, control panel design and layout
Diesel storage and distribution	Medium	Local and Control Room control panel design and layout, ease of maintenance (especially cleaning filters), control room interface
Chemical storage, distribution, and injection	High	Injection skid design and layout, skid location on facility, adequate access on skid for maintainability and operability, local control panel design, orientation and layout, control room interface
Accommodations Block Related		
Control room and equipment room	High	Layout, outfitting, ergonomics issues, spatial orientation, communication equipment, noise, lighting, ICS

System	HFE Priority	HFE Areas of Concern
Hospital and Medical Facilities	High	Location within accommodations module, layout and outfitting
Galley and Food Storage	High	Manual material handling activities, strike-down routes, layout, outfitting
Berthing and Recreation Spaces	High	Space size, layout and outfitting, berthing space location in regards to other spaces in accommodations
Workshops and Storage Areas	High	Location on facility, assisted lifting capability provided if needed, layout and outfitting of spaces, environmental control, access to deck cranes if needed
Machinery spaces	Medium	Adequate access for maintainability and operability, maintainability concerns, layout and outfitting
Laboratories	Medium	Location within facility, layout
Miscellaneous		
Cranes	High	Crane location, adequate access within machinery room for maintenance, location of crane(s) to provide maximum visibility of facility by crane operator, control and display design, dropped objects, provision of maximum visibility to supply boat, environmental control
Fixed hoisting equipment	Medium	Location of mechanical handling equipment, ease of access to lifting equipment, safety, ease of use, provision of sufficient laydown areas, reducing impact of dropped objects
Motorized trolley car		
Portable handling trolleys		
Rigging and slinging equipment		
Helicopter deck structure and surface, lighting, net, markings and fixtures.	High	Design of stairs leading to heli deck, portable safety barriers and location of helicopter refueling stations
Drilling and completions equipment, BOP and divert systems, mud systems	High	Driller's control panel design and layout, visibility, control room interface, control design, display design, adequate access for maintainability and operability, equipment removal and replacement, lighting
Stairs, ladders, escape routes and access platforms	High	Width, tread depth and riser height, handrails, landings, stretcher access, slip resistance material