Incorporating Human Factors Engineering Methods in the System Life Cycle of Offshore Oil and Gas Industries

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This paper highlights the importance of integration of human factors engineering (HFE) principles throughout phases of system life cycle of offshore energy industries. Human error is found to be the most common cause of offshore incidents according to the analysis of BSEE incident data. While human operators are mostly blamed for making errors and mistakes at the sharp end of a system, accident models and systems theory tell us that the cause of incidents are triggered much earlier in the system life cycle by the blunt end or managers and designers. Therefore, this proceeding provides HFE considerations for each step in system life as well as available HFE tools and methods to be employed. For corporate organizations to buy in proposed HFE methods, meta-analysis of cost-effectiveness for early HFE implementation is briefly presented.

Keyword: human factors methods, system life cycle, offshore installations, oil & gas production, user-centered design (UCD), human error, incident analysis.

INTRODUCTION

Human Error in Offshore Sector and Accident Models

Analysis of more than 800 offshore incidents reported to BSEE (U.S. Bureau of Safety and Environmental Enforcement) from 2003 to 2016 has shown that in approximately 50% of the reports, the leading contributing factor has been ascribed to human errors (BSEE, 2016). Such high percentage of human errors leading to offshore incidents does not come as a big surprise since similar results are also reflected in other industry sectors such as aviation (Wiegmann & Shappell, 2001). The fact that large portions of incidents take place at the 'sharp end (operators)' in the system has invoked the tendency of pointing out human operators' failure as an immediate cause. This view also influences the advent of many accident models that describe how human errors are situated in the chain of actions leading to an incident.

An early model of such thought that focuses on human errors is Heinrich's (1931) domino theory. The domino theory models accident causation as a simple linear relationship among different barriers. The last barrier is an accident itself and a barrier backward typically refers to human failures. This idea becomes more sophisticated in complex linear models, one of which is the Swiss cheese model as proposed by Reason (1990). Also called an epidemiological model, the Swiss cheese model differentiates acute conditions, *e.g.*, unsafe behaviour and latent or dormant conditions, *e.g.*, organizational impact, lack of supervision and pre-condition for unsafe act (Reason, 1990). These linear models, despite their limitation for more complex problems, explain a series of causal factors that cascade from the 'blunt end (managers and designers)' of the system. More thorough disassembly of a systematic failure is carried out by quantitative risk models. For example, Failure Mode and Effect Analysis (FMEA) is a standard tool used for identifying all possible failure scenarios and their consequences (Sheridan, 2008). Similarly, Fault Tree Analysis (FTA) and Event Tree Analysis (ETA) are developed to identify logical relationships and sequences that lead to the final outcomes. One conclusion which can be drawn from these accident models is that human operators' failure is not the cause of an incident; it is the manifestation of multiple causes combined in complex non-linear ways that leads to the incident (Qureshi, 2007). Consequently, humans, especially those working on the shop floor, cannot be blamed for their errors. Rather, more focus and effort should be placed all throughout the system in all segments of its life cycle to consider how their design and development affect the way the humans think and behave within the system. The fundamental impetus for such effort is that human fallibility and error-proneness are inevitable even in the most effective organizations (Reason, 2000).

This paper examines how various human factors and ergonomics (HFE) philosophy and principles can be embedded throughout the system's life cycle to eradicate human errors. Benefits of adopting HFE principles seem obvious in terms of performance and safety. This purpose of this paper, however, is to provide the guidance of how and when to select HFE tools and techniques with consideration of limited resources available in systems management along the life cycle of the facility.

Offshore Incident Analysis

BSEE was established in 2011 after the Deepwater Horizon disaster occurred in 2010 in an effort to reinforce regulatory administration over offshore energy and mineral production activities. In compliance with Outer Continent Shelf Lands Act (OSCLA, 1953 and Amendment in 2000), BSEE was granted authority to be informed of offshore incidents from the premises it oversights and to conduct investigation and provide a report based on the investigation. Based on these incident investigation reports provided by BSEE for the public, an analysis has been conducted to identify the trend of incidents reported, types of operations associated with the incidents and types of contributing causes. The database only contains self-reported incidents from 2003 to September 2016 and thus, may not be an exact representation of the actual number of incidents due to e.g., cover-ups. Figure 1 presents the number of incidents reported to BSEE in comparison with the amount of crude oil produced in the Gulf of Mexico (data: U.S. Energy Information Administration (EIA)). At a glance, there appears no significant correlation between two figures. Figure 2 and Figure 3 represent the types of operations that were being conducted during the incidents and types of contributing causes that were found from the investigation by BSEE, respectively. According to the analysis, 73% of reported incidents occurred during production and drilling operations. It is noteworthy that 49% of those incidents are caused by human errors and 32% by equipment failure. Including slip, trip and fall cases (5%), more than half of these incidents are related to human errors. Even though with this simple analysis it is evident that the human error is one of the main causal factors in offshore incidents, there is a lack of further effort to investigate how and why the human errors are made. Hence, the following section provides general theories about how human factors become a systems issue and not just an individual operators' fault.

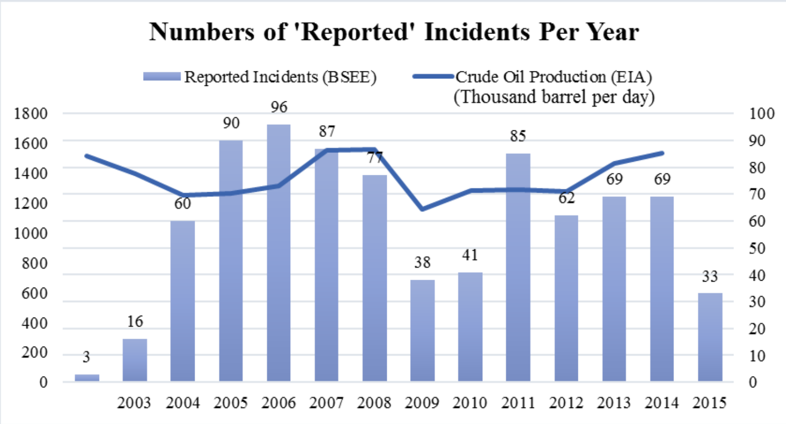


Figure 1. The Numbers of Incidents Reported to BSEE

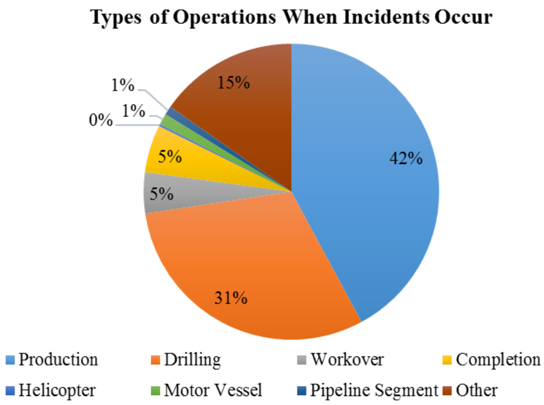


Figure 2. Types of Operations during Incidents

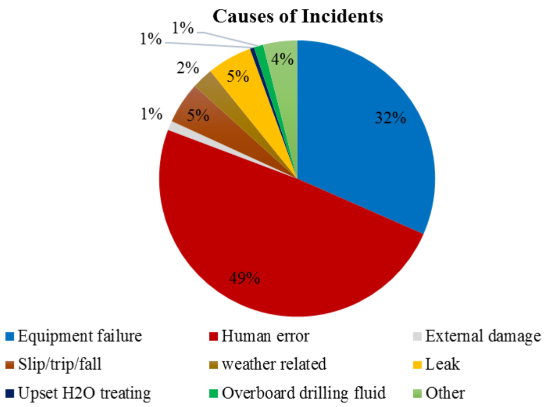


Figure 3. Types of Immediate Cause

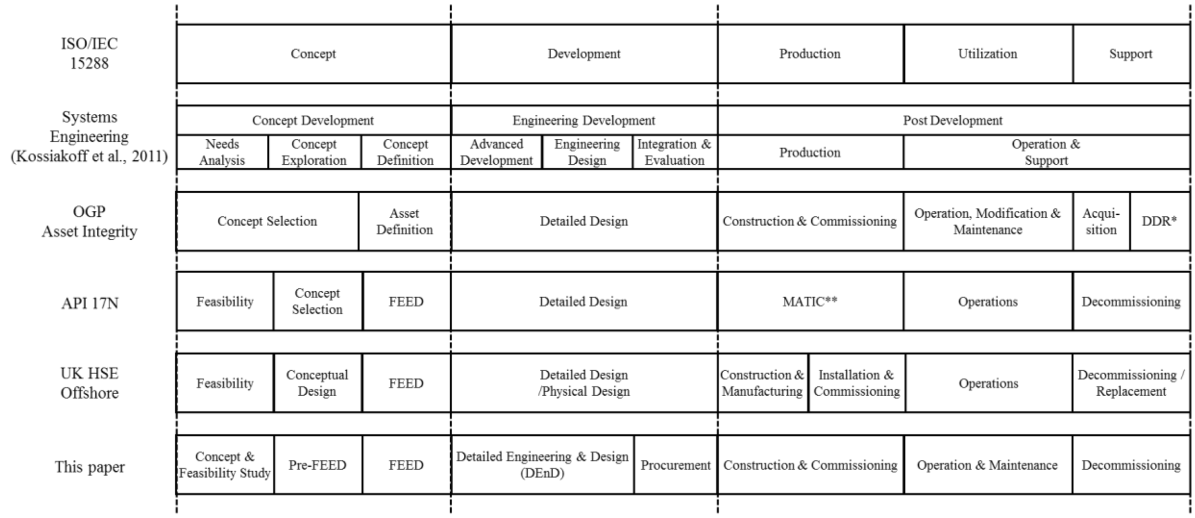
HFE METHODS INTEGRATION FOR OFFSHORE SYSTEMS

Human Factors as a Systems Issue

As human errors are considered a main cause of undesirable events, the needs of minimizing human control and intervention in complex systems are emphasized. This has flourished studies about automation based on the belief that a system can be created in which human involvement is minimized and so is free of any human error. However, this approach also brings surprises to human operators by making them less aware of current status in the system (Sarter, Woods, & Billings, 1997). Involvement of humans in design of such systems also results in flaws of such systems. Despite several benefits of automated systems such as better precision and higher productivity, increased complexity of the modern industrialized systems requires more proactive roles of human operators. By this it means that systems should be designed in a way that not only prevents human errors but also supports decision-making processes and adaptive performances. In that sense, Rasmussen and Vicente (1989) recognized the systematic influence on human errors and emphasized that human-system integration should capture the ways to manipulate the effects of those errors and not the ways to eliminate the human errors, per se (Rasmussen & Vicente, 1989). Accordingly, dealing with human errors necessarily involves design considerations throughout the system lifespan. Such design efforts, however, are not confined to design of equipment or control/display interface. Rather, it encompasses all aspects of systems design, development, construction, operation and support activities. Without understanding human being's capabilities and limitations, the overall system performance cannot be achieved as much as it intends to.

Offshore System Life Cycle

Most offshore oil and gas projects require huge capital investment and operate during relatively long system life cycle. This unique characteristic of the offshore projects brings two important aspects in terms of consideration of human factors. First, effort for incorporations of human factors should be made at earliest possible time since otherwise these issues are quite difficult and expensive to solve (HSE, 2002). Even though this is a universal issue regarding system design, offshore system may incur much more labour and cost due to its geographical isolation from support activities and spatial limitation for maintenance tasks. The second aspect deals with difference that emerges from phases of a system life cycle. While early exertion of HFE principles is always emphasized, different strategies for implementing HFE activities should be employed at various phases of the system lifespan. Before getting into the discussion of those HFE strategies, understanding of offshore system life cycle is necessary since there are some variations in its definition. Figure 4 represents the different definitions that can be applied to offshore oil and gas projects. According to Kossiakoff et al. (2011), a life cycle of a system can be divided into three stages: 1) concept development stage, 2) engineering development stage and 3) post-development stage and eight phases from needs analysis to operation and support (Kossiakoff, Sweet, Seymour, & Biemer, 2011). ISO/IEC 15288 (Systems and software engineering – System life cycle processes) largely aligns with this regime. While the overall classification still applies to offshore systems, some differences are identified from offshore industry guidelines and reports such as OGP Asset Integrity Report (OGP, 2008), API 17N – Recommended Practice for Subsea Production System Reliability, Technical Risk & Integrity Management (API, 2009), UK Health and Safety Executive (HSE, 2002). This paper adopts a system life cycle which combines different models as presented below.



* DDR: Decommissioning, Dismantling and Removal; ** MATIC: Manufacture, Assembly, Testing, Installation, Commissioning

Figure 4. Comparison of System Life Cycle Models

HFE Considerations through a System Life Cycle

Human factors engineering is a thorough system effort. Modern industrial systems are characterized by the complex interaction between human and technology. Offshore oil and gas systems, for instance, drilling rigs and FPSO (floating, production, storage and offloading) can also be considered as socio-technical systems in which human agents and technical artefacts are interacting towards the overall system's goals and objectives(Qureshi, 2007). Accordingly, the integration of human factors engineering depends on the varying phases of system life cycle. In order to address such changes and accommodate individual and organizational needs throughout the lifecycle, this proceeding explains different human factors aspects in each phase and proposes usable tools and methods to implement such considerations. On the other hand, return-on-investment (ROI) is the key factor for companies to accept HFE practices.

It is increasingly recognized that the realization of human factors effort in early phases offers the best benefit (McCafferty, McSweeney, Mawby, Conner, & de Koker, 2002). While early HFE implementation is always preferred, strategies and tactics need to suit for varying users and systems requirement. Those HFE strategic and tactical considerations along the system phases are illustrated in Figure 5 and corresponding descriptions follow as below.

Conceptual Design and Feasibility Study

In this step, production targets/goals are set and various systems that will together ensure this goal are defined and selected. This stage would require acknowledgement that HF considerations are to be taken into account and proper procedures are to be followed for implementation. The HFE Working Group is to be established in this stage, and should include personnel with necessary credentials and experience in HFE coming from the different participating groups and having representation in the project management team. This working group is to identify all required tasks with adherence to applicable standards and regulations and provide a timeline for completion of each task. Meetings/discussion should bring forth personnel and process safety, productivity, environmental factors, maintenance requirements *etc*. Most importantly, HFE Integration Plan (HEFIP) should be established at the initial phase in the life cycle. HFEIP is a consolidated document that specifies HFE roles and responsibilities for all the stakeholders throughout the system life cycle (McSweeney, de Koker, & Miller, 2008). Additionally, HFE awareness trainings can be provided to management, engineers and designers in this phase (ABS, 2014).

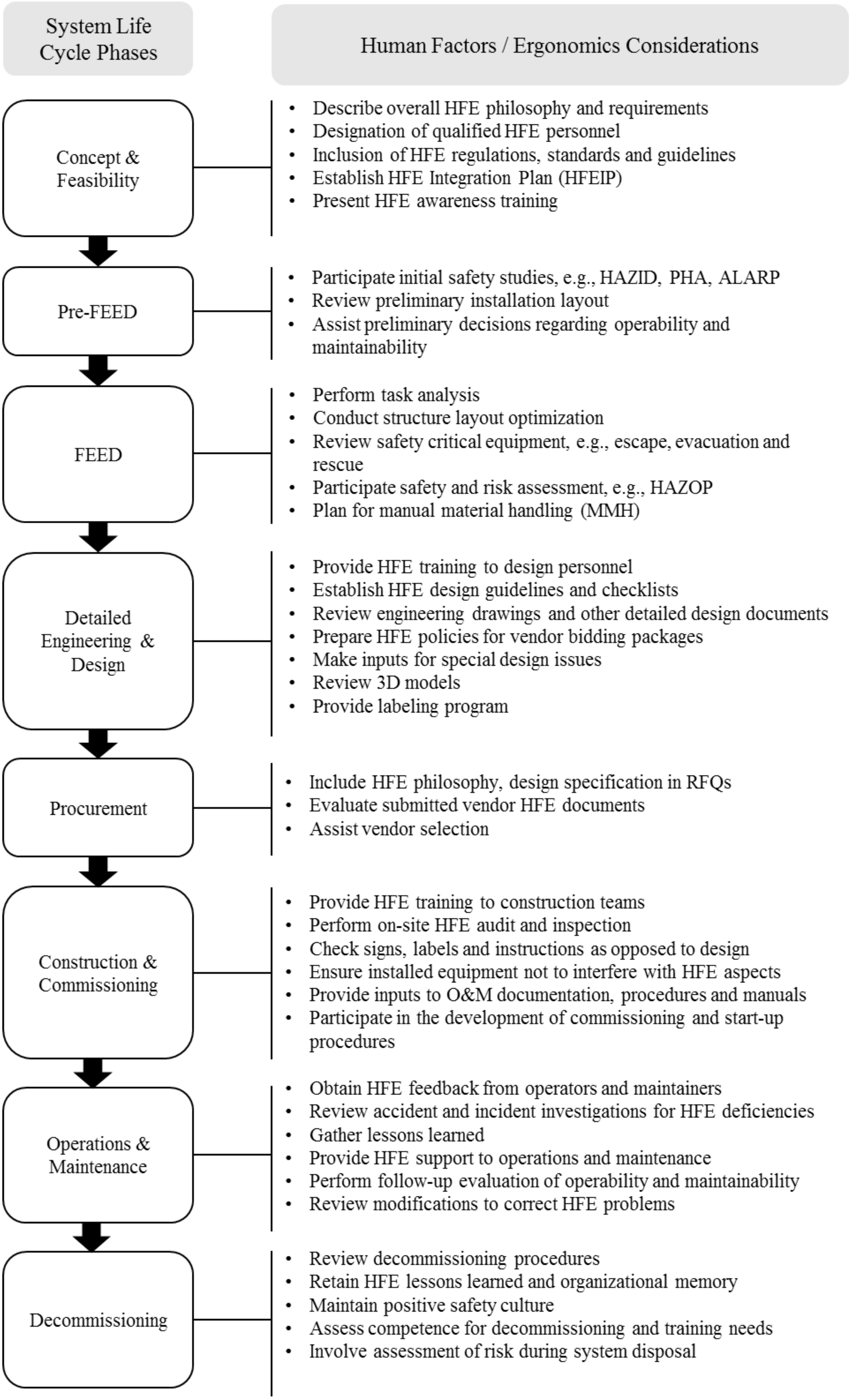


Figure 5. HFE Considerations along System Life Cycle Phases

Pre-FEED

Prior to the Front-to-End Engineering Design (FEED) stage it is essential to establish the philosophies and criteria that can affect safety, operability, maintenance *etc*. At this stage, the HFE personnel will provide inputs to the preliminary design and layout ideas that will ensure human factors are considered to the fullest. In addition, HFE personnel needs to provide input to initial safety studies, for instance, HAZID, PHA, human error ALARP (McCafferty et al., 2002).

FEED

HFE personnel at this stage are to use their credentials and experience to review and identify potential problems with the system being designed. They use the initial design to identify areas where human factors considerations are needed. To do this, task analysis can be practiced. Since there exist a wide variety of task analysis techniques, one has to choose the best methods in the discretion of HFE personnel. If the system has been used in a prior facility, HFE personnel work to identify problems that had already been identified and ensure that they are addressed in the detailed design phase. For new designs, HFE personnel works to identify possible problems such as those related to human-machine interface (HMI), control systems and alarm management systems, accessibility issues *etc*. so that these issues are mitigated during the detailed design phase. Major tasks to be considered in this phase include review of safety critical equipment (SCE) and escape, evacuation and rescue (EER) program. Manual material handling (MMH) program also needs to be established.

Detailed Engineering and Design

More detailed HFE trainings based on design disciplines should be provided to ensure that personnel involved in the detailed design are knowledgeable of the potential problems that may arise due to improper consideration of human factors. The 'best practices', potential sources of problems, previous mistakes in HFE design and required regulations should be included in such training. HFE personnel should provide guidelines and checklists to design groups to ensure all HFE principles are adequately reflected on designs. Once the detailed designs are produced, the HFE personnel should review such designs in depth including 3D CAD models. Operations manual and procedures are also to be review and a complete labelling of the facility is to be provided at this phase. Feedback from the reviews and suggested modifications are to be provided in this stage so that they can be addressed and corrected. Only through proper feedback loop will it be possible to ensure that all human factors considerations are incorporated in the design of the facility. Conducting HAZOP with HFE personnel in the group at this stage can ensure proper analysis and correction of design flaws of the facility.

Procurement

HFE requirements should be included in the documents for vendor bidding, which should include the established HFE guideline for the facility. HFE personnel should review submitted vendor bids and be a part of the selection process. Once vendors are selected and more detailed design become available, HFE personnel should review such documents to ensure compliance to established HFE requirements and finally ensure that the suggested modifications are included in the final design specifications.

Construction and Commissioning

HFE working group should ensure that selected contractor possess sufficient HFE knowledge and experience. HFE training is to be provided to the contractor personnel to make certain that all parties involved are in understanding of the established HFE requirements for current facility. HFE personnel should be present during test run of equipment and settings to ensure that all relevant HFE design intent has been established. HFE group is to ensure that the labelling of plant equipment in conjunction with that in the design. HFE personnel should actively participate in reviewing of the start-up and commissioning procedures and ensure requirements such as staffing are stringently met.

Operations and Maintenance:

HFE personnel should assist in the recruitment of operations and maintenance personnel, ensuring their level of understanding of human factors and their training and awareness of these factors upon employment. Once operation begins, the HFE personnel are to be involved in a feedback loop whereby they will gather HFE related information from the operations personnel, make/suggest changes, modifications or corrections and ensure they are addressed on time. Regular training should also be given to these personnel.

Decommissioning

Once a system is deemed to have reached the end of its operating life, decommissioning is considered. Since this process totally differs from normal operations and maintenance, HFE supports should differ from ones in other phases. However, little is known for the decommissioning phase (ABS, 2014). Nonetheless, it is anticipated that HFE principles be closely observed due to more uncertainty and thus elevated risk (Blackett, 2008). As done in the commissioning phase, HFE personnel should review procedures of decommissioning activities and attend safety studies if any. During this phase, the chance of losing documents and key personnel is high; retaining HFE related documents and user feedback should be pursued. In addition, influx of new workforce unfamiliar with the plant operation is expected. Therefore, HFE personnel should provide awareness training for the arriving employees against possible hazards.

HFE Tools and Methods during System Life

HFE considerations described above can be incorporated into actual practices by using suitable HFE tools and methods available. However, it is practically impossible to make an exhaustive list of every possible HFE techniques over system life cycle. Figure 6 provides some of tools and methods that are available to address HFE considerations. Overall, a majority of HFE activities are required to take place in the early stages of system development process.

First, target audiences are described at the very initial phase. A target audience description (TAD) is a task to define who will use the system under development (HSE, 2002). TAD provides basic sense of human body dimensions, physical and cognitive capabilities and limitations that are considered in equipment and interface design in later phases. While TAD puts its focus on users of the system, usability scenarios examine the most probable context in which the system is operated (HSE, 2002). After identifying potential users and contexts of the system, most of the HFE efforts are put into design phases. A majority of such activities begin at FEED and are continued afterwards. For example, physical and mental workload analysis is performed at this stage by using NASA Task Load Index (TLX) (Hart & Staveland, 1988). Whether to assign the workload either to human operators or automated systems is discussed in FEED. Automation can complement in workers' overload but it should be carefully determined since automation may cause other safety concerns such as reduced situation awareness, complacency and passiveness (Endsley, 1996). In modern complex offshore systems, interaction between human operators and machine, mostly computer is inevitable. Therefore, interface design, e.g., HMI, HCI influences operators' performance. This pertains to control and display designs that include monitor size, screen configuration, font size and color, icons, menus and alarm design (HSE, 2002). While HMI and HCI are common yet important topics for control room design, workspace and layout design applies to general workforce in offshore installations. As 2D and 3D CAD (computer-aided design) models become available at FEED, accessibility to machine and space, line of sight, ingress/egress can be discussed. A majority of workforce residing in offshore facilities are exposed to harsh environmental conditions such as thermal stress, constant vibration and shift work. Accordingly, design of offshore structure should study probable environmental context in which crews are performing tasks. This includes studies about illumination, temperature, noise, vibration, air conditioning aspect. There are several special issues to be considered in early design phases. Such special topics are, for example, manual material handling (MMH), valve criticality analysis and control room study. MMH is often required when lifting machines are not available. Due to the risk of getting injured from lifting heavy loads and downtime associated with blocked pathway, design for MMH should take place early, too. Valve criticality analysis (VCA) is a special subset of HMI. VCA refers to the study of evaluating the functional importance of valves and locate them according to the critically (ABS, 2014). While design effort in offshore systems is more essential that other HFE activities, HFE personnel should continue to provide post-design supports and receive feedback regarding design issues. For instance, they need to provide HFE awareness training and participate in incident/accident investigation to identify gaps that would have brought any human error or mistake. Based upon that, system-operating procedure can be updated to complement the design faults.

		Concept & Feasibility	Pre-FEED	FEED	Detailed Engineering & Design	Procure-ment	Construction & Commissioning	Operations & Management	Decom-missioning
Target audience description (TAD)		*	*	*					
Usability scenarios		*	*	*					
Task analysis		*	*	*	*		*	*	*
Workload analysis (e.g., NASA TLX)				*	*				
Functional allocation (human vs automation)				*	*				
HMI / HCI				*	*				
Alarm management				*	*				
User interface prototyping				*	*				
Workspace layout				*	*				
Human error ALARP				*	*				
System operating procedure					*	*	*	*	*
Environment study (light, temp., noise, vib.)				*	*	*			
Labeling study					*				
HFE training		*	*	*	*		*	*	*
Special Issues	Manual material handling			*	*		*	*	*
Special Issues	Valve criticality analysis			*	*				
Special Issues	Control room study			*	*				
Personnel selection					*		*	*	*
Human reliability analysis (HRA)			*	*	*				
3D CAD model review					*		*		
Incident/accident analysis						*	*	*	*
Team resource management (TRM)							*	*	*
Fast-time simulation /Real-time simulation			*	*	*				

Figure 6. HFE Tools and Methods for System Phases

Cost-Benefit Effectiveness of Human Factors Integration

The effectiveness of integration of human factors into the design, operations and maintenance of a facility are not as much reflected in literature as would be needed to provide a solid proof of its success. This is probably due to the lack of available data, or the reluctance of sharing data by facilities who utilize it. Also, the integration itself can be of various types. For example, some facilities may have implemented the concept of HFE in the design of control room for better human-machine interface in the conceptual phase of the plant life cycle while others may have implemented it well after commissioning and upon realizing that say, certain valves requiring manual operation only rarely were difficult to access and led to delays during emergency situations. In addition, various literature site cost and benefits in different terms. Some have reported cost of implementation as a percentage of plant total cost (Miller, 1999) while some have stated cost only in terms of personnel charges (Robertson, 1999). Benefits have been looked on as percentage increase in productivity, or decrease in the time taken to complete an operation (Hendrick, 1996) and so on. Such different applications and results give rise to varying costs and benefits and hence their comparison or utilization in performing a cost-benefit analysis for integration of human factors becomes very difficult.

Miller (1999) stated that implementation of a HOF program usually covered 0.08% of the platform acquisition cost and was never higher than 0.12% (Miller, 1999). This cost included the cost of assigning HOF personnel to the job as well as addressing the changes to materials and engineering designs of structure suggested by the HOF personnel. Robertson (1999) found that for the Sable project, incorporation of HFE was expected to be approximately 0.03% of the facilities budget. One of his reasons for such low percentage was stated as being due to the consideration of only personnel expenses and for not including the cost of implementation of changes suggested by the HFE personnel. Even then, if such cost had been taken into account, Robertson (1999) stated that the cost would have been less than 0.07%, which is in close agreement to that suggested by Miller (1999).

Hendrick (1996) gave a large number of examples from different types of HFE application in various industries and showed how benefits were obtained from implementation of HFE program. In an example he stated that redesigning of a semi-automated materials handling and stock keeping system had lowered the area noise level which increased productivity by 10% and paid back the redesign and development cost in approximate a year and a half. In his 2003 paper, Hendrick (Hendrick, 2003) sited Alexander (1999) showing the portion of engineering budget required for HF implementation at the various phases of the plant life cycle. This showed that while the application of HFE in the early/conceptual design phase may vary from 1-2.5% of the engineering budget, this cost may go up to 12% or more if implemented during normal operations. This may result due to the increased cost of making changes in the latter part of the system life cycle (European Organisation for the Safety of Air Navigation, 1999).

An important concept for budget allocation is the 'locked in' cost (Bruseberg, 2009; Charlton & O'Brien, 2001; European Organisation for the Safety of Air Navigation, 1999) which describe the amount of investment that has been allocated for investment in the upcoming phases of the lifecycle. The 'locked in' cost is significantly high, reaching approximately 70% by the end of the preliminary design phase in contrast to the actual cost which by this time may only be 1%. Thus, the impact of decisions made regarding designs is greatest at the conceptual phases of the plant life cycle, which is contrary to the actual expenditure made.

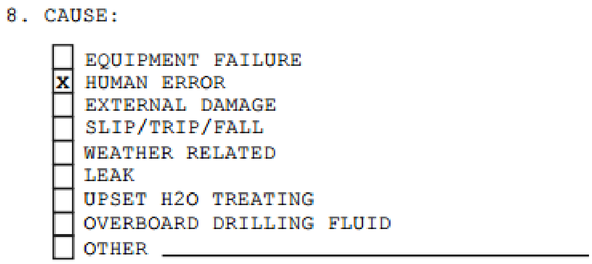
As outlined by Hendrick (2003), the cost of HFI implementation can arise from personnel cost (outside consultant, internal personnel), production and employee downtime, cost of purchasing equipment and material to comply with HFE suggestions and overhead costs(Hendrick, 2003). Other cost may include cost of office space for HFE personnel, costs of meetings and cost of training and awareness programs. Hendrick (2003) mentions benefits can arise in the form of personnel related benefits such as increased worker productivity, reduced error rate, number of incidents, required training time and reduced skill requirements, maintenance, absenteeism and turnover. If the HFE implementation is carried out at the early conceptual phase, then cost of purchasing equipment and materials for modifications (and also cost of changing the current system for an improved one) and production and employee downtime are eliminated. In addition, compensation cost for incidents related to HF is eliminated since an HFE implemented system is less likely to involve human errors and related incidents.

DISCUSSION

Operation of offshore oil and gas systems is hazardous and complex in nature. The significance of accounting for human factors and ergonomic aspects is demonstrated in several major catastrophes such as Piper Alpha (1988) and Deepwater Horizon (2010) incidents (Visser, 2011) and many others. Statistics of reported accidents/incidents indicate that human error is the most common cause of undesirable events. As a feed forward, this finding should be incorporated in the overall system development process. In spite of the urgent needs of appropriate human factors and ergonomics effort, there is still less focus on human factors both in design and operational phases (Johnsen, 2014). To aid in making decisions to accept and implement human factors engineering knowledge, this paper suggests a list of considerations and applicable HFE methods throughout the system life cycle. Complex systems such as aviation, nuclear and onshore/offshore oil and gas systems typically follow similar system development stages from concept to disposal. The application of HFE philosophy, however, can vary depending on the characteristics of users and contexts of the system. In particular, offshore facilities are quite unique in terms of design (more compact than onshore counterpart), operation and management (more uncertain and difficult to keep control). Consequently, HFE implementation strategy unique to offshore energy systems needs to be developed with further research.

On the other hand, providing guidelines and practical tools also matters in implementation of HFE philosophy. The life-long use of human factors inevitably requires continuous commitment at all levels in the organization. Top management commitment plays a pivotal role in allocation of sufficient resources and assigning HFE duty to personnel. Human factors engineering and design work should be verified against its original intent by examining workforce and system performance. Designation of HFE experts and due support for them are necessary conditions required to make human factors implementation successful (Pray, McSweeney, & Parker, 2014). Voluntary buy-in of human factors and ergonomics is desirable but slow and often ineffective. When it is agreed upon that best practices be mandated, putting these efforts in laws and regulations can give a quicker result. In fact, there are a multitude of HFE regulations, standards and industry guidelines are available today. An example is the OGP (International Association of Oil and Gas Producers) published the Report No. 454 regarding human factors engineering in projects (OGP, 2011). For control room designs, international standards such as ISO 11064 series are available. EEMUA 191 gives guidance on design, management and procurement of alarm systems. It is encouraging that the number of HFE regulations and standards is increasing but it is still not enough to cover all the phases of system life cycle. Hence, legislation efforts should sustain.

In the end, incident investigation is useful for providing input towards further improvement. However, in the incident analysis performed in this proceeding, the incident investigation reports do not provide detailed analysis about the cause or the influencing factors that lead to human error. The reports provide a brief description of the incident and reports in the format presented in Figure 7. Also, it seems that human errors are chosen when no other specific causal factors are identified. It is highly suggested to provide practitioners in offshore facilities with more detailed options for HF-related causes. Taxonomy of human errors – slip, lapse, mistake and violation – can be considered for those options and an in-depth analysis of the contributing causes should be conducted.


8. CAUSE:

- [ ] EQUIPMENT FAILURE
- [x] HUMAN ERROR
- [ ] EXTERNAL DAMAGE
- [ ] SLIP/TRIP/FALL
- [ ] WEATHER RELATED
- [ ] LEAK
- [ ] UPSET H2O TREATING
- [ ] OVERBOARD DRILLING FLUID
- [ ] OTHER ____________

Figure 7. A List of Causes in BSEE Incident Report

CONCLUSION

In highly complex and tightly coupled systems like offshore oil and gas production and drilling projects, human errors cannot be entirely eliminated but must be minimized. Nevertheless, this does not imply that human intervention and control be minimized as much as possible. Conversely, human operators' performance should be adequately supported by providing user-centred system design throughout the life cycle by means of a systematic approach. However, adoption of new, good technology and engineering philosophy does not take place spontaneously. Stakeholders in industries want to have an answer for 'why do we have to do this? (a bang for a buck)' and 'how can we achieve it?' To answer these questions, this proceeding, in part, presents some rationales and methodologies for successful HFE implementation along offshore system life cycle. The high portion of causes behind incidents that are deemed as human errors strongly support the argument that much greater endeavour is needed. This will include designating HFE personnel, particularly ones with expertise and corresponding authority to oversight through-system HFE initiatives. To make HFE knowledge transferable to the shop floor on the offshore facilities, industries, government and academia should collaborate in harmonious ways.

GLOSSARY

ALARP: As Low As Reasonably Practicable

API: American Petroleum Institute

EEMUA: Engineering Equipment and Materials Users Association

EER: Escape, Evaluation and Rescue

FEED: Front-End Engineering Design

HCI: Human-Computer Interaction

HFE: Human Factors Engineering

HMI: Human-Machine Interaction

HRA: Human Reliability Analysis

HSE: Health and Safety Executive (UK)

NASA: National Aeronautics and Space Administration

OGP: International Association of Oil & Gas Producers

TAD: Target Audience Description

TLX: Task Load Index

TRM: Team Resource Management

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