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Performance-Based Ergonomic Criteria and Evaluation Standards for Offshore Rig Evacuation Systems: Phase 1

Prepared for Transportation Development Centre
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by
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for
Consulting and Audit Canada

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This report reflects the views of the author and not necessarily those of the Transportation Development Centre.

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16. Abstract

This study focussed on the development of performance-based ergonomic criteria to evaluate semi-wet evacuation systems used on offshore rigs. The ergonomic factors were categorized under the following areas: management, training, procedures, information and communication, and environmental factors.

A table was developed that identified the relevant ergonomic factors for each evacuation stage, appropriate references, information still required, and performance-based criteria against which evacuation systems could be evaluated.

Recommendations address the need for a comprehensive review and analysis of ergonomic requirements for evacuation systems.

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16. Résumé

Cette étude visait l'élaboration de critères ergonomiques axés sur la performance pour l'évaluation des systèmes d'évacuation prévus pour les plates-formes pétrolières en mer. Ces critères ont été classés en catégories, selon qu'ils concernaient la gestion, la formation, les procédures, l'information et la communication, ou les facteurs environnementaux.

Un tableau a été élaboré sur lequel figurent les facteurs ergonomiques en jeu à chaque étape de l'évacuation, les références pertinentes, les données qui restent manquantes, ainsi que les critères de performance à l'égard desquels les plans d'évacuation peuvent être évalués.

Le rapport se termine par des recommandations qui soulignent le besoin d'une analyse poussée des facteurs ergonomiques à prendre en compte dans l'élaboration des systèmes d'évacuation.

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Summary

This study focussed on the development of performance-based ergonomic criteria to evaluate semi-wet evacuation systems used on offshore rigs. The continuum of evacuation systems extends from the moment a decision is made to evacuate the platform to the point when personnel are about to board the rescue vessel.

The ergonomic factors derived from the literature were categorized as follows: management, training, procedures, information and communication, and environmental factors.

A table was developed that identified the relevant ergonomic factors for each evacuation stage, appropriate references, information still required, and performance-based criteria against which evacuation systems could be evaluated.

It will be critical to ensure that future work entails an ergonomic analysis of the task of “using” an evacuation system. This necessitates an emphasis on *users* and what they do with the system, rather than on the system itself. At completion, the evaluation framework must be usable – it must focus on human performance aspects that reflect efficiency, effectiveness, user satisfaction, and, above all, safety.

Recommendations were made that address the need for a comprehensive review and analysis of ergonomic requirements for evacuation systems.

Sommaire

Cette étude visait l'élaboration de critères ergonomiques axés sur la performance pour l'évaluation des systèmes d'évacuation prévus pour les plates-formes pétrolières en mer. L'évacuation se compose d'une suite continue d'actions qui débute au moment où la décision est prise d'évacuer la plate-forme et se termine lorsque le personnel s'apprête à monter à bord du navire sauveteur.

Les facteurs ergonomiques en jeu, tels que tirés d'une recherche documentaire, ont été classés en catégories, selon qu'ils concernaient la gestion, la formation, les procédures, l'information et la communication, ou les facteurs environnementaux.

Un tableau a été élaboré sur lequel figurent les facteurs ergonomiques en jeu à chaque étape de l'évacuation, les références pertinentes, les données qui restent manquantes, ainsi que les critères de performance à l'égard desquels les systèmes d'évacuation peuvent être évalués.

Il sera très important de veiller à ce que les travaux futurs comportent une analyse ergonomique de la tâche d'«utiliser» un système d'évacuation. Cela suppose de mettre l'accent sur les *utilisateurs* et l'utilisation qu'ils font du système, plutôt que sur le système comme tel. Les travaux doivent déboucher sur un cadre d'évaluation utilisable, qui met surtout l'accent sur des caractéristiques reliées à l'utilisation concrète du système par le personnel : efficience, efficacité, satisfaction de l'utilisateur et, par-dessus tout, sécurité.

Le rapport se termine par des recommandations qui soulignent le besoin d'une analyse poussée des facteurs ergonomiques à prendre en compte dans l'élaboration des systèmes d'évacuation.

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1.0 Introduction

1.1 Relevant Background

Evaluation criteria for performance-based ergonomic criteria have been demonstrated to be critically lacking in numerous marine incidents, as documented by the Transportation Safety Board of Canada.

The complexity of human interaction in emergency conditions, such as during evacuation, requires that a comprehensive perspective of the *ergonomic* domain be applied. This perspective must consider the impact of cognition, psychological factors, sensory modalities, training, work conditions, and man-machine interaction on human behaviour and equipment and system design.

In fact, what is required is a set of guidelines or a comprehensive framework for a marine system that can address all the components of evacuation and their associated ergonomic requirements. Such a framework would permit designers, trainers, and operators of the evacuation systems to ensure it is appropriately tailored to man-machine interaction and that it is safe.

Thus, it is important to ensure that a detailed ergonomic analysis of "using" an evacuation system is undertaken, as well as the equipment and the environment in which it is used. This necessitates an emphasis on the users and what they do within the system (equipment), rather than on the equipment alone (the latter would simply be a human-engineering analysis). This approach ensures that the issues of interaction, functionality, and safety can be considered and viewed as a priority.

It is reasonable to show that evacuation systems can be used in extreme environmental conditions, but it is not clear why the equipment capabilities should be emphasized to the exclusion of all other factors. The basic question of "can the user use it" should guide the analysis and development. Furthermore, it will be imperative that the performance-based ergonomic criteria are exhaustive and validated prior to finalizing the evaluation framework.

Subsequently, this evaluation framework will be integrated into the more general technical criteria for evaluating offshore rig evacuation systems. These technical criteria are currently under development by stakeholders[1]. Additionally, these validated criteria could then be incorporated as guidelines into regulations governing the operation of offshore rigs.

At completion, the evaluation framework must be usable, in that it should focus on human performance aspects that reflect efficiency, effectiveness, user satisfaction, and above all, safety.

[1] Transportation Development Centre (TDC), Transport Canada; Frontier Lands Management Division, NRCan; Canadian Association of Petroleum Producers (CAPP).

1.2 The Role of Ergonomics

The following discussion addresses the importance of including ergonomics in the design, procedures, training, and risk analysis of offshore evacuation systems.

Offshore environments are complex by their very nature, and as such are difficult to assess. The external environment can be quite harsh, with a range of temperatures from $-20^{o}C$ to $-40^{o}C$; ice on the sea and platform; wind ranging from still to gale force; rain, fog, snow, sleet; icebergs; and wave heights ranging from 4 m to 8 m or even higher. Other hazards, which can often make escape difficult exist such as, personnel living in close quarters to the drilling devices, and the rig is surrounded by variable sea conditions.

Two recent offshore accidents were the Ocean Ranger in 1982 [1,2,3] and the Piper Alpha in 1988. Accidents and disasters result from a combination of unexpected circumstances potentially leading to outcomes such as explosions and fire and can often be coupled with bad weather. The Ocean Ranger accident is a good example of the impact of weather on the success of evacuation, where the personnel survived the capsize of the platform, but died in the attempt to transfer from a lifeboat to another vessel.

Tragically, lives were lost and such disasters may recur for several reasons:

- The design of platforms has been primarily limited to the operational needs, accommodations, and drilling for oil, not for evacuation systems [9];
- The design of evacuation systems has simply been adapted from conventional lifesaving equipment and from traditional hull-shaped vessels [9], thus circumventing the real need to conduct a full analysis of evacuation requirements;
- The design of evacuation systems has been restricted by available space on the platforms; and
- The interrelationships among all components of the evacuation systems – escape, evacuation, and rescue – have not been addressed.

Obviously, some reasons stated above are not mutually exclusive, but they nonetheless demonstrate current priorities. That is, until the design of evacuation equipment – in relation to the platform and interrelationships of the system components – is assigned priority over such concerns as limited space on platforms, the success and safety of evacuations will continue to be limited and more lives could be lost.

Ergonomics has engendered at least a half century of existence and experience, either as an engineering discipline or a design philosophy, and therefore, is not a new discipline. Yet, its acceptance and systematic application by trained specialists has been notably limited when one considers the impact on safety.

There are, however, several reasons why ergonomics may have been excluded in the design, development, and assessment of these evacuation systems.

First are the reasons stated above pertaining to priorities. The priority of personnel safety must take precedence over cost-effectiveness, space limitations, and questionable design of evacuation equipment and systems.

Second, designers and engineers are not trained in ergonomics and the little ergonomic training they may have had does not provide sufficient and necessary expertise.

Third, ergonomic consideration means that additional dollars must be assigned to R&D, but it has been common practice in most industries to cut what "appears" non-essential. This practice has always been considered acceptable, until a disaster strikes.

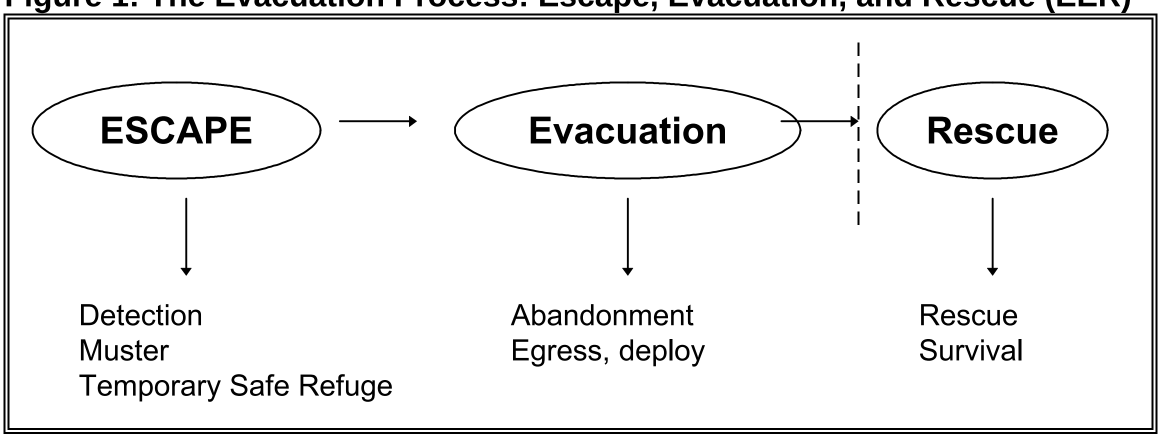
Ergonomics is, however, a relatively new focus for the offshore industry and, as in most industries, a developmental period must occur.

1.3 Project Scope

The overall focus of this report was to systematically develop performance-based ergonomic criteria that could be used to evaluate evacuation systems that are used on offshore rigs. This R&D initiative was to include an ergonomic component as part of the larger R&D activity on offshore rig evacuation systems. While there are three categories of evacuation systems, dry, semi-wet, and wet systems, only the semi-wet was the focus of this report.

Human interaction with evacuation systems can be envisaged along a continuum of essential components in the evacuation process – escape, evacuation, and rescue – as shown in Figure 1: **EER.**

Figure 1: The Evacuation Process: Escape, Evacuation, and Rescue (EER)



Consider a full sequence of EER events that could occur during an emergency:

a. the discovery (detection) of a hazardous incident, such as a vessel collision or explosion on the rig;
b. the alarm is raised, while mitigating measures to deal with the hazard are implemented;
c. personnel use pre-defined escape routes which have been selected to minimize or omit exposure to hazards, to muster to a location that is secure or safe from these hazards;
d. this location is the temporary safe refuge, where personnel await further mitigating actions or a decision to leave (evacuate) the rig;
e. if evacuation is necessary, personnel muster via predefined escape routes to the evacuation equipment;
f. once at the evacuation equipment personnel egress into the equipment;
g. the evacuation equipment is deployed from, and away from, the rig;
h. in some cases, personnel will deploy directly into the sea and can occur in parallel with egress into, or during the deployment of, the evacuation equipment; and
i. finally, personnel stay within the evacuation equipment or in the sea,
j. thus in the survival stage, until they are rescued by a third party rescue vessel.

Note: Steps “c” through “h” were the focus of this report.

The evacuation equipment reviewed for purposes of this report were as follows:

- inflatable liferafts
- totally enclosed motor-propelled survival craft (TEMPSC)
- TEMPSC conventional davit launch
- free fall
- preferred orientation and displacement (PrOD)
- seascape
- marine escape system.

1.3.1 Definitions

The scope of this report examined evacuation systems from the moment a decision has been made to evacuate the platform, to the point when personnel are about to board the rescue vessel, thus excluding the determination of the problem, the decision-making process leading up to the decision to evacuate, and aspects associated with the rescue effort.

Abandonment refers to all elements of egress and functionality within the system.

Deployment refers to launching the evacuation equipment.

Detection refers the cognitive and sensory processes used to discern that a hazardous incident has occurred, that requires any or all of EER.

Egress refers to entering into the evacuation equipment or rescue vessel.

Ergonomic environment refers to external personnel factors as time of day, awake-sleep cycles, point in work schedule cycles (e.g., early in shift; period of work time on the rig in a particular assignment); the structural conditions of the rig that may affect human performance for mustering and egress. External factors are those such as temperature, lighting, noise, and vibration, and internal factors such as cognition, which affect performance.
Escape refers to the process of removing oneself from the point of hazard.

Evacuation refers to leaving the offshore rig, either by using evacuation equipment or entering the sea directly.

Evacuation process includes the components of EER.

Evacuation system refers to any means of leaving the installation in a systematic manner, in an emergency situation, excluding dry and wet systems. An evacuation *system* may encompass more than the physical equipment deployed for abandonment. It may also include training, procedures, and steps in the evacuation process, and rescue.

Muster refers to access such as getting from point A to point B, where point B is the evacuation equipment or TSR.

Survival refers to residing in the evacuation equipment, at sea, once it has left the rig.

Temporary safe refuge refers to a physical location removed from the hazard, which serves as an area or structure that provides shelter from hazards.

Rescue refers to a third party intervention, which requires interaction with the evacuation system in order to retrieve individuals from the system.

1.4 Objectives

1.4.1 Consultations

To conduct consultations with industry, regulatory bodies, joint R&D partners, and the Technical Project Team as appropriate, to become familiar with:

a) The scope of the larger technical engineering project; and
b) Issues facing human performance and safety on offshore rigs.

1.4.2 Ergonomic Framework

Assess evacuation systems based on a selected literature and documentation review provided by Transportation Development Centre, Transport Canada, by:

a) Identifying, at a preliminary level, the performance-based ergonomic criteria using existing ergonomic models and evidence as guidelines for making decisions; and

b) Considering the environmental conditions based on a literature and documentation review as part of the identification of ergonomic criteria.

1.5 Deliverables

The report includes:

- Performance-based ergonomic criteria in the form of an evaluation framework;
- Identification of concerns for human participation in actual testing of evacuation systems;
- Identification of issues for human assessment in model and computer testing of evacuation systems;
- Identification of issues for further consideration; and
- Identification of the next steps and recommendations.

1.6 Considerations, Assumptions, and Limitations

1.6.1 Considerations

- Since the project focus was to develop performance-based ergonomic criteria a performance-based perspective was adopted. That is, a detailed performance analysis of the task of *using* a rig evacuation system was carried out at this stage. The emphasis was on how the evacuation takes place, not solely on the design of the equipment. This was achieved very minimally through documentation review only, and thus further extensive task analysis of the equipment and system on site and at the manufacturers' plant will be required to validate the framework.

- The starting point of the evacuation system was the point at which a decision was made to evacuate the platform. To this end, the method and quality of decision-making were not addressed. The end point of evacuation was defined as the commencement of rescue and so rescue was not assessed in this assignment.

1.6.2 Assumptions

- The criteria were developed in consideration of credible worst-case weather scenarios, based on existing research evidence provided through expert sources.

1.6.3 Limitations

- Despite the contract expectations that six to eight documents would be the basis of the review, numerous other documents were sought to provide additional and supplemental information. Most of the detailed equipment descriptions are available from manufacturers and will need to be secured for future work. Therefore, few public documents that describe the equipment or system in detail needed to assess ergonomic issues associated with boarding and operating these mechanisms were available.

- Documentation on regulation from other countries, such as the United Kingdom and Norway, may have revealed important information. However, the timeframe available did not allow for this activity.

- Site visits were not possible, so a thorough task analysis of existing evacuation systems and actual evacuation conditions was not possible.

- Assessment of the ergonomic environment under which evacuation systems are likely to be used was not possible at this time.

2.0 Methodology

2.1 Process

2.1.1 Kick-off Meeting

A kick-off meeting was held with the joint partners – National Research Council, Transport Canada, and Natural Resources Canada – to discuss the scope of the existing technical project and how the ergonomic framework would fit into the total project.

2.1.2 Review of Literature

A review of literature and documentation was carried out from the following sources:

- Documentation from IMD, National Research Council Canada and Transport
- Canada served as the main focus;
- Conference proceedings;
- Texts and journals from the offshore industry, oceanology, marine environment,
- and ergonomics arenas;
- Documentation of previous offshore accidents; and
- Personal communication with the joint partners.

The literature review focused on:

- elements of human behaviour observed in threatening situations;
- lessons learnt from previous incidents/accidents resulting in evacuation from an installation;
- ergonomic issues which have been addressed within evacuation equipment design and systems; and
- ergonomic issues which have not yet been addressed in evacuation equipment design and systems.

2.1.3 Regulatory Overview

A general overview of legislative and regulative jurisdictions referring to government department responsibility, certification process, and regulations was reviewed.

2.1.4 Identification of Decision Criteria

Identification of factors which will affect human performance during evacuation.

2.1.5 Identification of Ergonomic Performance-Based Criteria

Identification of appropriate performance-based ergonomic criteria, against which to evaluate the evacuation systems.

2.1.6 Major Assignment Tasks

Six tasks comprised this assignment:

- meetings;
- documentation gathering;
- documentation review;
- framework development;
- reporting; and
- project management.

2.2 Categorization of Ergonomic Factors

The ergonomic elements included in the framework were categorized into the following way:

- management;
- training;
- procedures;
- information and communication;
- physical design of escape routes, evacuation equipment, for example; and
- environmental factors such as lighting, noise, thermal environment, and vibration.

The above categories are all external performance-shaping factors. It was also necessary to consider internal performance-shaping factors or those factors which could cause detriments to the cognitive process of evacuating an offshore installation and which may lead to irrational behaviour. Internal performance-shaping factors tend to manifest themselves in external behaviours and this was annotated within the table wherever it was considered relevant.

This categorization was based upon two models of human behaviour:

A. Performance-shaping factors as defined by Swain [4] and the Meister [5] classification system addressed:
    - inadequate workspace and work area design;
    - poor environment;
    - inadequate human engineering design;
    - inadequate training and job aids (procedures); and
    - poor supervision (management).

B. The general systems model defines the human as one element in a system affected by management, training, procedures, design factors, and the working environment.

These models were considered appropriate to identify performance-based ergonomic criteria because:

- all the above components must exist in order to achieve evacuation process; and
- the optimization of less than all of these elements will not result in a successful evacuation process.

2.3 Development of the Ergonomic Framework

The performance-based ergonomic framework developed is compatible with the framework developed by Magellan [6]. Magellan's three major components *closely* correspond to the following elements of the ergonomic framework developed for this report:

Ergonomic Framework	Magellan Framework
elements and description	reference EER assessment
task review or analysis	field specific EER assessment
performance-based ergonomic criteria	output

Table 1: Comparsion of Frameworks

One major difference between the two frameworks is that Magellan's is based on a risk analysis approach, while the ergonomic framework is based on consideration of tasks comprising evacuation. Furthermore, in the Magellan report the reference assessment component contains aspects related to their outputs. Ergonomic elements are listed in the report's *Element* column.

The ergonomic *elements* were identified and grouped into categories such as leadership, and a description was provided to ensure that the definition of the ergonomic *element* is clear. Table 1 indicates the stage of evacuation (EER) for which the elements are relevant, the information sources, factors to review [or alternatively, that which is missing], and ergonomic performance-based criteria against which evacuation systems could be evaluated. The reference to impairment criteria identified in the Magellan Report [6] relates to the identified

The *Evacuation stage* identifies which major step in the evacuation process – EER – the elements pertain to.

A general *description* of key issues pertaining to these elements is provided.

The *Sources of Information* column contains a reference number that corresponds to the documents used. This provided a trail of information used to compile the table. Any one factor could be addressed in a number of different references.

The *Factors to Review* column identifies any information that was not available to the authors at the time the table was produced, but which would enhance the quality of the assessment tool if available in the future.

Performance-based ergonomic criteria against which evacuation systems could be evaluated were defined in the final column of the table. They represented the qualities of the evacuation system which were considered desirable, and would allow the assessor of the system to determine whether each particular criterion could be met, not achieved at all, or to what degree it had been met.

The following components of an evacuation system were also considered in the development of the framework:

- signals
- boarding the evacuation mechanism
- exiting the rig
- movement to the muster location
- detection of incidents
- routes and procedures used to evacuate the rig
- means of ingress into the evacuation system
- procedures for launching the evacuation system
- means of operating the evacuation system
- means of survival in the evacuation system; and
- means of navigating away from the rig.

3.0 Results

The framework was derived by a detailed ergonomic assessment that:

- Identified the primary ergonomic elements of the framework. This identification process utilized the performance shaping factors as defined by Swain [4] and Meister's [5] classification system, and a general systems model to guide the selection of the criteria; and

- Listed the ergonomic criteria needed to evaluate each element. The framework considered each element in terms of its stage in evacuation process, description, or background on the element, sources of information, and further information required.

The relevant performance-based ergonomic criteria are contained in Appendix 1.

3.1 Performance-based Ergonomic Criteria

A number of the performance-based ergonomic criteria specified in the framework (Appendix 1) are based on existing validated facts found in the literature, such as criteria pertaining to leadership, command structure, feedback mechanisms, design, training, communication, and information.

Performance-based ergonomic criteria against which evacuation systems could be evaluated represent the qualities of the evacuation system which were considered desirable, and which would allow the designer, operator, regulator, etc. of the system to determine whether each particular criterion could be met, not achieved at all, or to what degree it had been met.

Given the limited information available for this report, much more work is required to identify the criteria for the evacuation equipment. Nonetheless, the criteria thus identified reveal a clear practicality and that provision of such criteria for any aspect of the evacuation process is possible.

In some cases the criteria are:

- very specific, providing clear requirements;
- require the identification of metric requirements (e.g., speed x density x width); and
- identify what criteria are employed currently.

The framework is too broad to summarize any one area or to identify key aspects. In fact, it is our contention that all aspects of the evacuation process are essential, key aspects to safety. That is, failure to meet minimum performance-based ergonomic criteria at one step in the EER process or aspect of each of EER, could result in lost lives.

The minimal/maximal or acceptable variance in standard levels for all criteria in the framework must still be determined. Additionally, a priority ranking between elements and criteria within elements could be undertaken to guide decisions regarding changes and implementation. This will require a risk analysis approach.

3.2 Other Factors

Throughout the development of the framework, it became evident that a number of factors influence the safety and success of EER that are common to several *elements* and *performance-based ergonomic criteria,* i.e., the factors are interrelated. Our review and discussion of these are by no means exhaustive, but the following brief discussion serves to provide examples of this inter-relatedness.

For example, *panic* during emergency situations has the potential to be greatly reduced through training, communication, and the provision of information to personnel, and demonstrated leadership during the evacuation process.

Mustering is one of the first major steps in the evacuation process during which many things can go wrong, thus affecting subsequent success of evacuation process – EER. It is clear that the success of mustering addresses such issues as training effectiveness, panic, environmental hazards and weather conditions, time available, and TSR options. It also requires leaders who will ensure an effective command structure.

Another such factor is *training*. Within reasonable limits, the training drills must address all possible and credible options and also include the use of the equipment and evacuation routes. The lessons learned from each drill, based on feedback, communication to personnel, and observation by training staff, will not only enhance further training, but also shed light on important requirements for procedures, and on the design of TSRs and evacuation equipment.

It will be crucial to consider the role of training programs in using evacuation equipment and systems, as well as the effects of human behaviour in response to stressful conditions. It is known that training sessions are restricted in terms of realism.

The ideal situation is to ultimately conduct practice drills with the actual evacuation equipment that will be used on the rigs. However, this situation is considered unsafe, for a myriad of valid reasons, so alternatives have been pursued. However, some of these alternatives do not provide experiences that will be close to the real situation. For example, indoor pool simulations using a slide have been devised, but the slide is less than 15 m high. Nonetheless, simulation cannot be designed to create anxiety toward using the system [17], this is an ongoing dilemma.

Other simulations must be reviewed and assessed to identify cost-effective improvements and/or identify the implications of the limitations in these simulations. This can only be done once a thorough understanding of training procedures and regulatory requirements is achieved. The review of the regulations regarding training is necessary to ensure that the performance-based ergonomic criteria can be attained through current training approaches, as well as recommendations for improvements.

This table identifies the *some* of the key questions that will have a significant impact on the future development of the performance-based ergonomic evaluation framework.

Key Questions	Success Factors
How to ensure all factors are incorporated.	• Adopt a broader "systems" approach. • View evacuation as a continuum, not just one element in time, location, or as a physical entity.
Are the performance-based criteria appropriate?	• Establish measurable performance criteria. • Establish valid performance indicators. • Rely on known facts from ergonomic R&D. • Identify level of standard desired (minimal, maximum).
How to ensure that professional judgements are objective.	• Utilize a validated evaluation framework. • Establish agreed-upon protocol, goals, objectives.
How to provide consistency in evaluation.	• Utilize a validated evaluation framework.
What assurances can be made that the system is fault sensitive or that the error "ceiling" is not set to high or low.	• Utilize risk analysis techniques suitable to human behaviour. • Develop appropriate human reliability measures. • Incorporate risk assessment in the evaluation framework.

Table 2: Summary of Key Successes

3.3 Offshore Regulatory Regime

A thorough review and analysis of regulations was not been possible at this time. A general review of the overview and summary of this regime by Veitch [7] revealed that the relationships and responsibilities between the players – Transportation Canada, Frontier Lands Management Division of Natural Resources Canada, and the Canadian Association of Petroleum Producers – will require a detailed review of legislation and protocol statements to identify the impact on human performance and behaviour related to evacuation systems (e.g., training requirements and manufacturing hardware requirements for evacuation systems).

3.4 How to Use the Framework as an Evaluation Tool

The framework, while unfinished, can now be used. This framework can be used to guide the development of most aspects of evacuation systems, for example, identifying muster routes, designing evacuation equipment, or specifying training protocol.

Notably, when the design of this assessment tool is added to, modified and refined, it will be necessary to determine whether it will be useful for the assessor to determine merely whether the criterion has been met or not, or whether some form of rating scale should be developed to state to what extent it has been met.

First, one must determine what aspect of the evacuation system one wishes to consider. Once this is decided, the user can identify a specific aspect of the factors and stage of evacuation. Performance-based criteria are then provided for this specific focus. Supporting information is also given that connects the criteria to the factor by way of describing the factor, as well as providing evidence to substantiate the criteria and/or any other information that is needed to identify the criteria.

For example, consider *Training Needs* under Training Factors – see page A-3, column 1, “Ergonomic Factors”, (Appendix 1). This factor pertains to all evacuation stages, as indicated by the second column “Evacuation Stage”. A general description pertaining to what is encompassed by this factor is provided in the third column – “Description”. “Information Sources” supporting the performance-based criteria are cited in the fourth column and is referenced at the end of this document.

In some cases further information is required in order to complete the development of this specific performance-based criteria – see column five “Information Required” in the fourth column. The performance-based criteria for training needs are identified in column six.

4.0 General Discussion

4.1 Future Considerations

4.1.1 Concerns Related to the Participation of Humans in Evacuation System Testing

A. Unrealistic evacuation times may result in testing for a number of reasons:
- lack of urgency to move quickly as the participants know there is no real hazard;
- conversely, quicker times may be yielded due to the lack of obstructions or hazards; and
- people may not take the exercise too seriously.

This will be important in considering the comparison of evacuation times against the time the rig is likely to remain habitable in different emergency circumstances.

B. It is unethical to create any potentially harmful situations, so there will be no real indication of how personnel would behave in those circumstances, i.e. there is likely to be no panicking (no irrational behaviour). The following is therefore NOT likely to occur in exercises:
- confusion about which route to take thus perhaps causing congestion in some routes;
- perhaps or moving towards the hazard in other situations;
- movement towards familiar routes instead of safe routes;
- pushing and shoving; and
- tripping on stairs.

In short, it is not possible in testing to train people to deal with all possible scenarios. Hence, the emphasis must be placed upon familiarizing personnel with all evacuation scenarios and equipment to the greatest extent possible.

C. There will be no injured people who require assistance. This may be a mistaken assumption and is not founded on objective data.

D. The use of the evacuation mechanisms to remove personnel from the oil rig places personnel in potentially hazardous situations. For example, a free-fall lifeboat will expose personnel to a certain g force. Exposure to these kinds of hazards is not acceptable on a frequent basis. The risks are worth taking in a real evacuation, considering that the alternative is a threat to the lives of the personnel who remain on the installation.

4.1.2 The Neglected Element – Panic

Panic has been defined as irrational behaviour when faced with a threatening situation. Note: flight behaviour is not considered to be panic behaviour, because flight is rational. Deaths in major accidents have been attributed to panic. However, whether “panic” has received sufficient attention as a significant contributor to unsuccessful evacuations is questionable.

A great deal of literature addresses panic and its associated behaviours (i.e., confusion, trauma, fear, disorientation, etc.). A significant amount of work has been directed to such human behaviour in large crowds, airline disasters, in fire situations, and buildings on fire [8, 9, 10]. Findings based on these studies have resulted in changes to legislation, building codes, fire regulations, and design. Incidents can escalate very quickly and, coupled with the time it takes for the escalation, the time available to evacuate may be extremely limited (e.g., 10 minutes) [11].

Little consideration has been specifically directed at panic behaviour in offshore installations during emergency situations. What is often neglected is the consideration of how panic affects evacuation performance and judgment. Fitzgerald et al [11] examined the theory and implications of ‘panic’ relating to Piper Alpha. Several ergonomic issues were identified for improvements by Fitzgerald et al [11], and the need to ensure that information is conveyed to personnel under a full disclosure condition was evident. Keeping personnel well-informed may reduce the likelihood of panic, facilitate training, and thus ensure a more effective evacuation process. The Fitzgerald et al [11] work points to the need to review and consider training, the development of procedures and policies, and the design of equipment with the “panic” factor in mind.

4.1.3 Risk

Risk can be reduced through improved training and increases in human reliability. Risk can also be significantly affected by design and layout of the evacuation equipment or the evacuation process, for example.

No one proven method to assess human risk is available. Consequently, operations that rely heavily on human skills have been difficult to assess and determine in terms of quantifying risk levels [12].

Methods of risk analysis have largely been derived from the nuclear and chemical industries, and only recently have been applied and/or modified to the offshore industry [12]. Traditionally. risk analysis has focused on verifying that a platform concept can be operated at minimum of risk to personnel and the environment during serious events. The focus has been primarily on mechanical errors (as opposed to human errors or some combination of the two) [12]. Consequently, the underlying cause of incidents, accidents, and disasters has been neglected [12].

Traditional Risk Analysis Methods

Traditional risk analysis methods have entailed the following:

- Hazard identification (failure mode and effect analysis);
- Hazard and operability analysis; and
- Quantitative risk analysis.

Modifications to the Traditional Risk Analysis

Modifications to the traditional risk analysis methods should consider the following:

- Incorporating realistic simulations in both computer and full-scale modeling and training;

- Incorporating valid human error analysis techniques. An integrated process for investigating human error has been developed by the Transportation Safety Board. This process has been successfully applied to the investigations of transportation accidents [13]. What is needed is a similar analytical model approach that focuses on the prevention of accidents.

Nonetheless, further work is required and will be essential to the validation of the framework.

4.1.4 Ergonomic Model Testing and Validation

The evaluation framework must also be validated for scale-model, full-model, and simulation testing scenarios, with the inclusion of acceptable estimates of risk.

Model testing is complex and the authors do not have an awareness of the parameters and requirements of human model testing. Incorporating the human element into models has been challenging, but clearly not formidable, as the automobile industry's crash-test dummies have shown. A similar application has been considered in testing offshore evacuation systems. Waugh et al [14] used an instrumented Hybrid III anthropometric test dummy to assess injury risk of free-fall lifeboats, and the EVACSIM [15] simulates the egress of personnel from various locations on the platform to the muster station.

Further consideration should also be given to computer modeling and such a review has been provided by Newbury [16]. For example, the National Research Council computer modeled the bobsled course for the 1988 Calgary Olympics. Similar approaches could incorporate the elements of human limitations for force acceleration, anthropometric measurements with/out floatation suits, and muster routes with various obstructions on offshore rigs.

Model testing could be optimized once a thorough task analysis has identified performance-based ergonomic criteria.

5.0 Future Work

Two major components comprise the next steps, of which only the first will be elaborated upon:

- Completion of the performance-based ergonomic evaluation framework; and

- Validation the performance-based ergonomic criteria and complete framework.

5.1 Further Development of the Ergonomic Evaluation Framework

The following steps are methodological requirements to complete the development of the ergonomic evaluation framework:

5.1.1 Regulatory Documentation Review

The review of the regulatory documentation and processes are necessary to:

- ensure that the performance-based ergonomic criteria do not conflict with current regulations; and
- identify which regulations and/or processes could be modified to ensure ergonomic soundness of evacuation systems.

5.1.2 Extensive Consultations and Further Documentation Collection

Based on the review of legislation and safety procedures, consultations could be conducted in order to seek clarification and additional information about the regulatory process and equipment and procedures.

Six consultation groups are envisaged:

- regulatory bodies;
- offshore companies responsible for managing the offshore operations, training, etc.;
- manufacturers of evacuation systems;
- researchers at scale model testing laboratories;
- education staff at training facilities;
- foreign associates (e.g., offshore companies, regulatory bodies); and
- offshore personnel.

A number of lessons can undoubtedly be learned from other countries that have faced similar issues and questions regarding evacuation systems. In particular, we have knowledge that the United Kingdom has developed an offshore department as part of their Health and Safety Executive, of which ergonomics is one area of concern. Once their documentation is obtained and reviewed, a directed interview guideline can be developed for face-to-face discussion. A contact person in the U.K. has already been identified.

5.1.3 Task Analysis

The literature review in this report focused on lessons learned from past accidents and on research and experimental data that has been collected to date by others. The table of ergonomic factors affecting the success of evacuations cannot be considered complete unless further assessment of the equipment and procedures used are conducted.

A site visit is required to offshore rigs and manufacturers' plants for the following purposes:

- to observe the offshore environmental conditions;
- to carry out a task analysis of evacuation scenarios to further define where
- performance may be affected; and
- to observe and record details of the different evacuation mechanisms, how they are operated, and define specific ways in which human performance will be affected.

The task analysis should entail the following:

- Detailed task and human error analysis of existing rig evacuation systems should include, but not limited to, functional and operational procedures, each associated with the components in Figure 1; and

- A necessary step to considering how systems may fail and what could go wrong is to include the technique of error identification and analysis. A suitable method or combination of several methods must be identified.

The evaluation framework as a tool must be seen to be thorough and comprehensive in the eyes of the licensee to maintain the credibility of the regulators, encourage "buy-in" by the licensees, and ensure that the process is successful, i.e. that it achieves the goal of improving evacuation systems on offshore installations.

6.0 Recommendations

- Consult with foreign industry and governments to gain knowledge from their lessons learned.

- Conduct the task analysis in parallel to the review of training, regulations, and detailed specifications on the equipment.

- Develop performance-based ergonomic criteria for *each* step in the evacuation process (e.g., detection, muster, abandonment, survival, rescue), beginning with the evacuation equipment.

- Develop the performance-based ergonomic criteria based on existing categories (i.e., procedures, management, communication, and information).

- Review and identify appropriate measures of human risk pertaining to ergonomic performance and safety of evacuation systems.

7.0 Conclusions

The successful implementation of a performance-based ergonomic evaluation framework directed at evaluating evacuation systems will depend on considering the evacuation system in its totality. That is, the sum of the parts will not equal the whole, so unless human behaviour is considered in relation to all features of the complete system the analysis will be incomplete.

To understand how to positively affect human behaviour in evacuation systems requires addressing the management systems, safety procedures, and protocol, in addition to the examination of training, procedures, and equipment design. For a systematic and detailed assessment of the evacuation systems and development of the performance-based ergonomic criteria be undertaken the analysis needs to be transparent and flexible to accommodate technology evolution and to review different systems.

Each evacuation system has its own set of limitations, design, and survival challenges. Hence, a framework of generic performance-based ergonomic criteria will be just that – *generic* – and reveal the common and essential features. If superficial assessments are made, assurances of safety will be lacking. On the other hand, overly detailed assessments will be quite costly, perhaps without additional benefits and can lead to unrealistically stringent standards.

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Appendix 1

Performance-based Ergonomic Criteria

Framework for Ergonomics Performance-Based Criteria and Evaluation Standards for Offshore Rig Evacuation Systems – Phase 1

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Management Leadership and decision-making skills (Internal Performance-Shaping Factor)	All	It is imperative that the OIM displays leadership qualities in an evacuation scenario.	1, 2, 5, 7	Recruitment requirements, policies and procedures for OIMs	Psychometric tests are used during the recruitment process to assess whether the candidate possesses effective leadership and decision-making skills. OIMs are specifically trained in the areas of leadership and decision-making, and there is frequent refresher training.
Command Structure (Internal Performance-Shaping Factor)	All	A recognized, clearly defined, and logical command structure is necessary.	1, 2, 3, 5, 7		A command structure is clearly identified for emergency scenarios, identifying roles and responsibilities of relevant staff. This is compatible with the command structure in normal conditions. Back-up contingencies are presented in the event of injuries/incapacitation of personnel with key roles.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Feedback mechanisms	All	It is important to learn lessons from previous drills and training sessions, as well as incidents and accidents.	1, 14	Regulatory requirements regarding the recording of training exercises Regulatory requirements regarding change control processes A log is kept of training exercises and drills, and a debriefing always take place.	A successful mechanism exists, and is documented in policies and procedures, to feed information from lessons learnt into emergency training and procedures. A mechanism exists to share experiences of accidents and near misses between installations/companies.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Communications and Information Provision of adequate information to evacuees (Internal Performance-Shaping Factor)	Detection of incident Escape (To Muster) Evacuation (Board evacuation mechanism) Towards rescue/ ongoing	Information should be provided to personnel about the nature, severity and possible consequences of the hazard, and clear directions should be given about the action they should take. Clear information should be given about the location of the hazard and the most appropriate route to take and the destination. Any necessary protective equipment should be identified and the location communicated. Method of evacuation should be identified and instructions should be given about the safe embarkation. Any further information about future actions, precautions etc. should be provided.	4, 10, 11, 5, 6	Is there a process for the identification of credible scenarios requiring evacuation e.g. the production of a safety case to be submitted to the regulators? The precise nature of the hazards to which personnel on the installation may be exposed. The nature of the hazards to which personnel may be exposed when they have evacuated the installation, but before boarding the rescue vessel	Procedures identify the information to be communicated to the personnel being evacuated for each unique set of circumstances identified as credible. The communication includes unique identification of each route to be taken by personnel at different locations. Information to be communicated includes unique and specific instructions as to which method of evacuation to use, precautions to take, and alternatives in specific sets of circumstances.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Communications facilities	All	Facilities for communication both to personnel and other parties should be clearly identified, taking into account possible failures, and other performance shaping factors such as smoke, noise etc. (redundancy).	7, 14	The extent of the noise, smoke, etc. in which communications systems are required to function	Regulations regarding reliability and redundancy of equipment redundant communications facilities are provided in event of failures (e.g. for PA systems), and consideration has been given to performance shaping factors such as noise and smoke in areas where communications are to be seen and heard. PA and alarm systems can operate for 6 hours in the event of a loss of electricity generation capability. Redundancy is provided in the means of communicating to personnel in each area.
Lines of Communication (Internal Performance-Shaping Factor)	All	The lines of communication between different roles within evacuations should be clearly defined and supported to ensure that communications are efficient.	7		It is clearly documented in the procedures (and forms part of the training) who is expected to communicate with whom, regarding what information
Communication Protocol (Internal Performance-Shaping Factor)	All	The content and presentation of communications should addressed to ensure that a common (industry familiar) language is used, and that the content is unambiguous.		Industry standard for communication within the offshore oil and gas industry	Training and procedures address the communication protocol e.g. the presentation of the communication, the terminology and sentence structure to be used, to eliminate ambiguity and create efficient communication.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Training Training Organization	All	Organizational mechanisms need to be in place to support training initiatives, and one of the important issues is adequate funding.	Experience 14		Adequate funding is available to support evacuation training.
Training Needs	All	Training development should be based upon a comprehensive analysis of the actions required by all personnel during an evacuation for different evacuation scenarios.	Experience 14	Regulations regarding the development of training Industry practice regarding the development of training	An analysis has been carried out of the actions to take when evacuating by the different methods available, in different evacuation scenarios. This has been used to define the training needs of all personnel.
Training Design	All	The content, instructional techniques and training delivery should be appropriate for the type of material to be delivered.	Experience 14	As above	Training is carried out for the use of all protective equipment, fire fighting equipment, etc. and the use of all the evacuation methods. It addresses the procedures to be followed. Adequate use of on-the-job training and simulation training is used to create situational awareness.
Training Control	All	It should be ensured that feedback from the training experience is used to further improve the training. Notes/records should be kept of training drills/exercises.	7	As above	See feedback mechanisms.
Contractor	All	Even temporary workers must be familiar with the evacuation systems	1, 2, 3	As above	As above also for contractors

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Level of Training	All	The personnel need to categorized so that the appropriate content and level of training is directed at each job role/emergency role	7, 12, 14	As above	Training needs are explicitly identified and documented for each role of personnel on the rig Adequate training is provided for the crews operating the lifeboats, leading to certification which has a specified renewal frequency.
Safety Induction	All	It should be ensured that all personnel receive evacuation training for that specific oil rig immediately they are on board.	1, 2, 3, 14	Regulations regarding the immediacy of evacuation training All personnel receive evacuation training before they commence operations on the rig.	Course content addresses * response to alarms * roles and responsibilities * lifesaving * fire fighting * use of survival equipment * use of evacuation equipment
Refresher Training (Internal Performance-Shaping Factor)	All	When equipment/systems, routes etc. are used infrequently, people forget how to use them. In emergency situations people take routes/use equipment that is familiar to them, even if it is inappropriate for that situation.	1, 2, 3	Are there regulations here or in UK which addresses frequency, or should we compare to another high hazard industry such as nuclear?	Refresher training is carried out on a frequency of *? to ensure that training using each piece of evacuation equipment is experienced every *? We don't have the information to specify this – it may be covered by other regulations.
Continuing training (Internal Performance-Shaping Factor)	All	When new equipment is added or any aspect of the evacuation system is changed, there will be a new set of circumstances to deal with during an emergency	1, 2, 3		A change control mechanism exists whereby the implication of any changes to equipment or procedures is assessed for its impact upon the success of the evacuation system As a result of this, retraining is carried out in a timely fashion.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Frequency of Drills (Internal Performance-Shaping Factor)	All	See refresher training Drills should be carried out at unexpected times so that a false success is not achieved due to a level of preparedness	1, 2, 3, 14	Industry regulations	See above
Timing of Drills	All	In a lot of cases drills are carried out at the same time each week/month and so the personnel are alert as they are expecting the drill.	1, 2, 3, 14	The times of the day that drills are initiated vary each time there is a drill and include the use of off-hours.	
Content of Drills	All	If drills do not address all possible/credible scenarios and the use of all evacuation equipment, the personnel will not become comfortable and familiar with these situations The aim of the drills should be to increase the comfort levels of the personnel during evacuation, and not create anxiety when using the evacuation equipment which will impact upon evacuation performance in the future	1, 2, 3, 15	Regulatory process - how credible scenarios are defined and communicated to the regulators	A plan is drawn up for each drill detailing the scenario, location of the hazard, complications and errors, means of evacuation, communications facilities and personnel involved and any other relevant information. Each credible scenario identified by the safety analysis must be addressed every *? As for drill frequency
Procedures Completeness of Procedures	All	Emergency procedures need to address all possible/credible scenarios.	1, 2, 3, 7	As above – Is there a safety case, which defines all the credible scenarios?	Emergency procedures exist for each scenario identified as credible by the safety case
Definition of Roles and Responsibilities (Internal Performance-Shaping Factor)	All	Procedures must clearly define the roles and responsibilities of those involved in the evacuation to avoid any confusion	1, 2, 3		The roles and responsibilities of all personnel involved in the evacuation are clearly defined in the procedures.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Sound basis for procedures	All	Procedures must be based upon the definition of credible scenarios, an understanding of these situations, and sound technical knowledge.	Experience	As above	See completeness
Procedures Design (Internal Performance-Shaping Factor)	All	The procedures should contain clarification aids where appropriate, e.g. diagrams and schematics, and should not contain any redundant information. Document design standards.	Experience		Procedures contain schematics of the rig showing evacuation routes, location of communication facilities and protective clothing, and evacuation equipment in relation to occupied areas of the rig. Decision-action trees are used where relevant to assist in procedure Clarification.
Document Control	All	If there is no document control process to ensure that only up-to-date procedures are used, there may be some omissions or discrepancies which could lead to unsuccessful evacuation	Experience		A document control process exists whereby the number, location and owner of each copy of the procedures is identified, and old procedures are removed as soon as new ones are issued. This process is documented in policies and procedures.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Design Width of Evacuation Routes	Escape (To muster)	Evacuation routes should be designed to accommodate the expected flow of traffic, and should be of uniform width to avoid bottlenecks	1, 2, 3, 7,11, 24	There are some models which define flow rates relating to number of personnel and specify appropriate widths of stairways, passages, etc. Reference 7 states escape routes should be a minimum of 910 mm wide Should we specify a width or ask licensees to demonstrate they have used a valid model to define the width during their design process?	An equation/calculation such as: speed x density x width of route has been used to demonstrate that each area on the rig can be successfully evacuated before it becomes uninhabitable The evacuation routes do not have any bulkhead mounted items from the floor up to 38 inches, and from 53 to 77 inches to prevent injuries (ref. 24).
Location of evacuation routes	Escape (To muster)	Evacuation routes need to available from all locations to muster points, bearing in mind constraints imposed by the hazard itself, and the potential locations for hazards.	1, 2, 3	Existing regulations/ standards which address these issues	Evacuation routes exist from all potentially manned locations on the platform to the evacuation mechanisms
Availability of Evacuation Routes	Escape (To muster)	There should be two available evacuation routes, for every location which must be evacuated	7	As above	Two separate evacuation routes exist from all potentially manned locations on the platform to the evacuation equipment.
Design of Exits	Escape (To muster)	The doors should open in the direction of the expected flow of traffic	7	As above	All doors open in the direction of the expected flow of traffic.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Stair design	Escape (To muster)	The edges of the stairs should be obvious, the tread size should provide adequate footing, and handrails should be provided.	11	As above	Handrails are provided on every stairway and are *? high (anthropometric data to be inserted). The edges of stairs are marked with luminous yellow paint to ensure they are obvious in situations of poor visibility. The stair dimensions are ? (Appropriate standard to be used).
Number of Exits	Escape (To muster)	There should be sufficient exits for occupancy numbers.	7	Reference states that for 1-60 people = 1 exit, 60-500 people = 2 exits	Again, do we make specific recommendations or just require the licensees to demonstrate they have considered this issue. This will be based upon the answer to the question posed in the previous column.
Alarm system design	Escape (To muster)	Alarms with different meanings should be easily discriminable. Alarms should be detectable against background noise and so should be at least 15dBa louder.	3, 9 8, 9	Is there an industry standard?	
Alarm testing	All	Alarm testing should occur on a regular basis to ensure that the system is operable.	3	Is there an industry standard?	Alarm testing is carried out on a frequency of ? This will be based upon the answer to the question posed in the previous column.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Information system design	All	Where computer screens are used, the displays should adhere to industry standards for screen layout, content, the size of lettering and colour coding. The location and positioning of the monitors should also be addressed.	9	Is there an industry standard?	This could be a fairly extensive section – there are a lot of guidelines relating to this issue – How far do we go here? We would need more specific information about evacuation systems to be able to complete this section.
Provision of Temporary Safe Refuge (TSR)	Escape (To muster)	A place should provided for personnel to gather before exiting the platform, that is safe, and where they can receive further instruction son how to proceed.	16, 17, 19, 21	There must be regulations that address this issue	Calculated time required for the personnel to muster and proceed to evacuation mechanism There is a TSR which provides protection from fire, heat, smoke, radiation, toxic fumes, explosions, and other hazards. Protection can be maintained long enough for all personnel to gather and for decisions to be made on how to evacuate the platform. Adequate available communications mechanisms exist in this location.
Evacuation equipment design	Evacuation from platform	This section will be specific for each piece of evacuation equipment – it is envisaged that the task analysis performed on site and discussions with relevant experts will allow us to provide further detail here.			

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Availability		To evacuation equipment Incident investigations of Piper Alpha and Ocean Ranger indicate that there were insufficient lifeboats accessible.	14	There are sufficient lifeboats to accommodate 200% of the personnel to be evacuated, and their location has taken into consideration the possible location of hazards.	
Access		To evacuation equipment The personnel evacuating the rig will probably be wearing survival suits and will need to get into the lifeboats on the platform.	12, 13, 14, 20	Position of the lifeboats, and detailed design details to indicate how they are accessed How long it would take for the last person to board the life raft and compare it to estimated survival times in the sea. For lifeboats boarded on the platform the design needs to verify that they can be boarded successfully by all personnel before the rig becomes uninhabitable.	Life rafts are not the primary means of evacuation from the installation. Life rafts have inflatable boarding steps or ladders with hand rails and have been tested to show that they can be accessed by each person wearing a survival suit within *? (see questions in previous column) seconds, if they have to be boarded from the sea Life rafts can be davit launched. An escape slide is provided to assist entry to the raft from the rig.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Ease of Launching	Evacuation	The launching mechanism should be easy to operate in the expected environmental conditions, without excess force on the part of the operator, within a specified time frame.	12, 13, 14, 24	Exact details about the equipment used and the steps taken to successfully complete launching	The launching mechanism can be operated by *? number of personnel, within*? Minutes (see previous column). Automatic launching is possible in the event of a sudden catastrophe. Launching can be completed from inside the lifeboat. The design of the launching mechanism has considered and minimized the likelihood of human error, and consists of the minimum number of action steps. The design has minimized the likelihood of collision with the platform upon entering the sea.
Acceleration during launching	Evacuation	See Environmental Conditions			

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Stability of launching	Evacuation	Details of different methods of evacuation used Is there a process for the identification of credible scenarios requiring evacuation e.g. the production of a safety case to be submitted to the regulators There is a high likelihood of capsizing upon entry into the sea, and difficulty in righting the vessel again with life rafts, for example. In addition, the release mechanism of the lifeboats is sometimes activated prematurely by high waves.	12, 13, 14	Information on the design of launch and release mechanisms. The evacuation equipment can be launched from heights which accommodate all possible evacuation points from the platform.	The vessel is self righting or the likelihood of capsizing has been demonstrated to be low. The release mechanism design is such that it cannot be released too soon. Launching results in the effective movement of the escape vessel away from the installation to avoid the possibility of collision.
Stability in the water	Evacuation	There is still a chance of capsizing in severe weather conditions. In the case of life rafts, high winds may cause them to move away from the rig before all the personnel can board.	12, 13, 14, 23	Any regulations which address stability	The lifeboats have been demonstrated to remain stable in winds of *? km/hr and waves *?m high (9m?) for a period of *? (See questions in previous column.) (p131: 40 knot winds, 17 m wave height, -20 degrees C, sea temp of -1.8 degrees, visibility of less than 1 km – gales last up to 48 hrs and storms up to 15 hrs) Life rafts are fitted with drogues (sea anchors).

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Stability of personnel in the escape vessel	Evacuation	The winds and waves may cause excessive movement of the vessel which may lead to injuries.	12, 13, 20, 21, 25	Any existing regulations	Seat belts are provided for all personnel. Head rests are provided on each seat.
Thermal environment	Evacuation	See environmental conditions.	12,13	Suitable temperature for personnel wearing survival suits Lowest temperature conditions to which the personnel are likely to be exposed	The primary means of evacuation from an installation should maintain an internal temperature of *? for *? Minutes (See questions in previous column.)
Other hazards	Evacuation	There may be explosions, fire, releases of toxic gases, etc.	12, 13	Likely hazards	The escape vessel is gas tight. The escape vessel is flame-proof. The escape vessel can maintain an inside atmospheric pressure of equal to, or within 2kPa of the outside atmospheric pressure.
Provisions for injured personnel	Evacuation	There may be incapacitated and injured personnel using the escape vessel.	12, 13	Estimated number of injured per evacuation	The escape vessel has room for *? number of stretchers with belts to secure them (see questions in previous column).
Preventative maintenance	Evacuation	It must be ensured that there are no latent human error and equipment failures causing the evacuation mechanism to fail upon demand.	12, 13	Acceptable frequencies for maintenance Redundancy has been built into the system so a component failure does not lead to a failure to operate.	Preventive maintenance tasks and frequencies have been comprehensively documented in a maintenance plan, and records are kept of the maintenance activities which are carried out, on what dates, and any problems.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Environmental Conditions Lighting in evacuation passageways	Escape (To Muster)	Emergency lighting must be sufficient for personnel to successfully move along the escape route.	9	Recommended lighting levels for escape routes are about 30 lux – will find a reference	Availability and reliability targets Lighting levels of 30 lux are provided in escape routes. Availability meets targets.
Noise	Escape (To muster) Evacuation Mechanism	Noise levels continuously above 85dBa will damage hearing, and above 65dBa will not permit successful communication.	8, 9	What are the possible noise levels to which personnel will be exposed?	
Thermal environment	Escape (To Muster) inside Escape (To Muster) outside and Evacuation Mechanism	A person's comfort zone or "vasomotor regulation zone" should be maintained. Inside that temperature range is 20 to 23 degrees C.	8, 18, 22	What are the possible temperature conditions to which the personnel may be exposed? We must define appropriate protective clothing	Worst case definition of time personnel are expected to survive in the sea before rescue. Survival suits and life jackets are provided for 200% of personnel on the installation. Survival suits are located at several suitable locations within the escape routes, muster, and TSR areas. Survival suits are designed with required buoyancy and permit the wearer to remain upright in the water. Survival suits permit visibility.

Ergonomics Factors/Elements	Evacuation Stage	Description	Information Sources	Factors to Review	Performance-Based Criteria/Standards
Vibration and acceleration	Escape (to muster) Evacuation mechanism	Vibration becomes intolerable: * below 2Hz at accelerations of 3 to 4g * between 4Hz and 14Hz at accelerations of 1.2 to 3.2g * above 14Hz at accelerations of 5 to 9g	8, 15, 20, 21, 25	Again what are the likely vibrations and accelerations to which the personnel will be exposed?	References 20 and 25 make recommendations about acceptable g forces.

Information Requirements

There are four main categories of information required before this table could be completed:

- information about Canada's current regulatory process with respect to evacuation systems
- information about existing standards and regulations with which the performance-based criteria must be compatible
- information about "best industry practice" here and in other countries such as the UK
- more information about the evacuation mechanisms themselves

In addition, there is a major issue to be resolved before successful development of such an evaluation tool can be accomplished; that of the required level of prescription. For some of the Ergonomics factors such as lighting level for example, the requirement is clear and based upon data. That is the most suitable lighting level for an emergency walkway has been demonstrated to be 30 lux. For other issues however such as the frequency of refresher training, the performance-based criterion is not so clear cut. There has been proven suitable frequency for offshore evacuation refresher training (as far as we are currently aware), and so it is not possible to specify a definite required frequency as the performance-based criterion. The criterion can only request proof that the a suitable refresher training frequency has been determined.

It is not clear at this time what level of prescription is required by the client, nor if it is possible to adopt one or the other level, rather than a combination of the two.

N.B. Where the performance-based criteria still have ?, this represents the fact that the information requirements stated in the previous column have not yet been fulfilled, but would assist in the clarification of the criterion.

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