



# Human and organizational factors assessment of the evacuation operation of BP Deepwater Horizon accident



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## ABSTRACT

The offshore oil and gas industry is applying more advanced technologies to explore and produce petroleum in challenging environments. To meet the demands of these conditions, operators need to take suitable precautions relating to emergency response and evacuation procedures in terms of technology, management, operations, and personnel competence. The successful evacuation operations are dependent upon comprehensive preparedness should an incident occur. However, many reports of offshore accidents reveal that human factors contribute to the failure of evacuation. This paper addresses and discusses the contribution of human and organizational aspects to the evacuation operations of the BP Deepwater Horizon accident using a proposed framework. The framework consists of the evacuation protective layers and the evacuation preparedness plan. Human and organizational factors are discussed and analyzed at different stages, that is, the organization, personnel's competence, the evacuation procedures, and the emergency equipment. As a result, insufficient emergency drills and exercises, poor communications, impairment of personnel's physical ability due to unsafe conditions, and poor emergency preparedness planning were identified as human and organizational factors contributing to the unsuccessful evacuation operations of the Macondo well blowout.

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## 1. Introduction

Escape, evacuation, and rescue (EER) from offshore installations is a last line of defense in preventing loss of life and serious injury from unsafe and hazardous conditions, such as well blowouts, uncontrolled fire, an impending or actual ship collision, extreme weather, loss of containment of a riser or subsea pipeline, and loss of containment in the process facilities (IADC, 2010; Wallace, 1992). Unsuccessful EER operations can have tragic outcomes with a high number of fatalities, such as the Piper Alpha platform disaster, the Alexander L. Kielland accommodation platform collapse, and the Ocean Ranger tragedy (Cullen, 1990; Skogdalen et al., 2012; USCG, 1983).

Human and organizational factors play a role in the unsuccessful or unsafe evacuation of offshore structures. Failures such as the late activation of a general alarm, personnel's ability to act being compromised by the hazards, incompetent management of lifeboats and life rafts, lack of command and control, as well as

communication problems have been identified in many evacuation operations of offshore accidents. Many qualitative and quantitative studies on EER in offshore installations have been done by human factors researchers (Basra and Kirwan, 1998; Gould and Au, 1995; Musharraf et al., 2013; Woodcock and Au, 2013; Yun and Marsden, 2010). Studies involving human errors in EER often result in recommendations such as improving EER training (Deacon et al., 2010; DiMattia et al., 2005; Kennedy, 1993; Skogdalen et al., 2012). However, there is a lack of studies that relate the human and organizational factors to individual characteristics, the emergency equipment, the EER procedures, and a system concurrently, which could affect the success or failure of EER operations.

This paper proposes a framework for addressing human and organizational factors issues based on the barriers related to the evacuation operations. The main purpose of this framework is to identify and assess the contributions of human and organizational factors in evacuation operations that lead to an unsafe evacuation. Evacuation outcomes in the BP Deepwater Horizon accident are studied using this proposed framework. This will provide insight into human responses during emergencies that may help to improve emergency evacuation systems. The discussion emphasizes the contribution of human factors associated with environmental, organizational, and individual characteristics.

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## 2. Development of a framework for assessing human and organizational factors in the evacuation operations of BP Deepwater Horizon accident

### 2.1. Defining evacuation operations

Evacuation can be defined as a process of leaving an installation and its vicinity, in an emergency, in a systematic manner and without directly entering the sea (Cullen, 1990; HSE, 1997; OGP, 2010). Successful evacuation will result in persons being transferred to a place of safe refuge, meaning a safe onshore location, or a safe offshore location or marine vessel with suitable facilities.

For this study, the evacuation operations sequence follows basic EER stages as provided by OGP (2010). The sequence begins with an initiating event resulting in an evacuation, which is when the offshore installation manager (OIM) assessed the severity of the unsafe conditions and decided to abandon the installation. It follows the sequence of an evacuation alarm, translation through emergency routes to a muster point and then to an egress point. Finally, the sequence considers leaving the installation as a final stage.

### 2.2. Framework for assessing human and organizational factors in the evacuation operations

This paper introduces three (3) components as indicated by a gray box in Fig. 1. Those components are the development of evacuation protective layers, identification of human and organizational factors in the evacuation protective layers, and comparison of the evacuation operations with an evacuation preparedness plan. The information obtained in the human and organizational factors assessment will be meaningful to enhance evacuation preparedness planning and improve the effectiveness of evacuation operations. Each component is further described in Sections 2.2.1–2.2.3.

#### 2.2.1. Development of evacuation protective layers

The evacuation preparedness generally consists of the installation's organization, personnel, evacuation procedures, and emergency equipment. Fig. 2 shows the evacuation preparedness as a series of protective layers. Applying the protective layers, or barriers, in the evacuation preparedness could increase the likelihood of successful evacuation operations. The protective layers are dependent on each other to reduce the risks associated with emergency scenarios.

According to industry-based guidelines, operators of an offshore installation play a critical role in the evacuation preparedness (CAPP, 2005; CAPP, 2010; HSE, 1997; IADC, 2010). The installation's organization represents the outermost layer of the evacuation

preparedness. At this level, the organization will decide on the quality of evacuation preparedness applied to the installation. The organization's choice of the level of quality for evacuation preparedness can directly affect the risk to offshore personnel. Placing evacuation procedures and emergency equipment before the protective layers of personnel is meant to shield personnel from emerging hazards. Personnel must follow the evacuation procedures while using the emergency equipment to assist them to move towards a designated safe area and subsequently to abandon the installation.

Unorganized and inadequate evacuation preparedness could result in four non-ideal outcomes, based on the accident sequence event tree (Kujath et al., 2010; Rathnayaka et al., 2011):

- (i) *Minor Accident*: An event with faulty emergency equipment of evacuation operations that may cause minor or major injuries (Cai et al., 2013; Skalle et al., 2014).
- (ii) *Accident*: An event with faulty emergency equipment and inadequate evacuation procedures that may cause major injuries and temporary or permanent disability (Vinnem et al., 2012).
- (iii) *Major Accident*: An event with faulty emergency equipment, inadequate evacuation procedures, and incompetent personnel that may cause one or more injuries, fatalities, and damage to property (Akhtar and Utne, 2014).
- (iv) *Catastrophic accident or disaster*: An event with faulty emergency equipment, inadequate evacuation procedures, incompetent personnel, and poor organization that may cause multiple fatalities and extensive damage to property, production, and the environment (Mohaghegh et al., 2009).

#### 2.2.2. Identification of human and organizational factors in evacuation operations

The barriers related to the mitigation of unsafe conditions or the susceptibility to human factors can be described by Reason's Swiss cheese model. Breaches in these barriers can be due to unsafe acts or undetected defects. The presence of holes in one barrier does not necessarily cause a significant negative outcome. A fatal outcome can happen when holes in many layers momentarily line up to allow a trajectory of incident opportunity to bring hazards directly to unprotected victims (Reason, 2000). Based on Fig. 3, the catastrophic accident would only happen if the emergency equipment, the evacuation procedures, personnel, and the organization concurrently failed to maintain impenetrable barriers.

Consideration of human and organizational factors in the evacuation preparedness of offshore installations is a key to successful responses or performances during the evacuation operations. The organization must first recognize human factors in the organizational structure of evacuation preparedness, which can be safety culture, documentation, evacuation procedures design, emergency

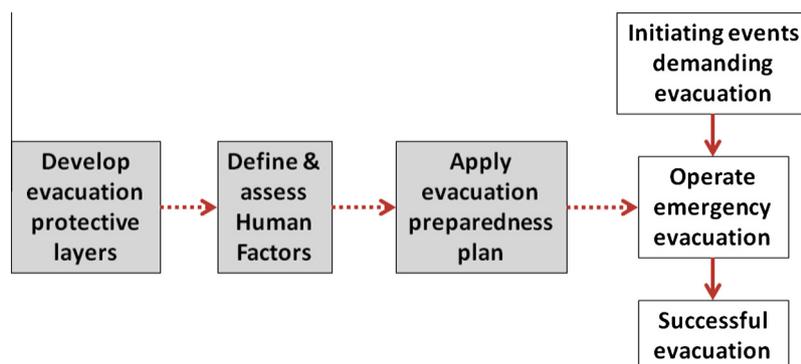


Fig. 1. A framework for assessing the contributions of human factors.

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