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# HUMAN ERROR PROBABILITY IN THE EMERGENCY EVACUATION PROCEDURES OF THE OFFSHORE PLATFORM

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*SUMMARY: This study aims to determine the human error probability during the emergency evacuation of offshore platforms with the HEART technique. In this study, after completing an emergency maneuver with a fire and explosion scenario, the HTA method was used to identify and segregate the emergency evacuation activities, and the HEART technique was utilized to estimate the human error probability. Lastly, suitable control measures were suggested based on the evaluation's findings. In the event of a fire and explosion, the safest means of evacuating people and leaving the platform include evacuation by lifeboat, evacuation by rescue floats and rescue ships nearby, and evacuation by helicopter. Due to the extreme risk, evacuating individuals via life rafts and jumping directly into the water is not recommended. It is advised to examine the safety state of the platform, organize specialized safety training and weekly maneuvers for personnel participating in the emergency evacuation procedures of the platform, and monitor the repair, maintenance, and inspection status of the employed equipment.*

**Key words:** *human error, offshore platforms, emergency evacuation*

## INTRODUCTION

One of the major causes of critical accidents in procedures industries is human error, which has resulted in billions of dollars in material damage and the loss of experienced personnel in the sensitive facilities of various industries. Mishaps such as the space shuttle Challenger explosion, England's Deepwater Horizon, and the Chernobyl nuclear power plant demonstrate that humans play a role in industrial accidents *(Grozdanović et al., 2006)*. According to a study in England, 80% of marine accidents are due to human error *(Goulielmos., 1997)*. Human error plays an effective role in accidents and is one of the main causes of accidents in high-risk industries *(Azhdari et al., 2017)*. Accidents in the offshore industry are largely attributable to human error; occasionally, they play a key role owing to direct actions or faulty design *(Khan et al., 2006)*. Human error is one of the most fundamental human elements that can lower individual tasks performance quality, safety, and efficiency in an integrated system. Human error is the deviation of human performance from established rules and responsibilities that exceeds the system permitted limit and negatively impacts system efficiency *(Amir-Heidari et al., 2015, Habibi et al., 2011)*. Due to the harshness and complexity of the offshore industry working environment, the incidence of accidents may be

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extremely unpleasant. Past incidences can determine the significance of job disruption, accumulation, and evacuation in emergencies *(Robertson et al., 1997, Vinnem, 2014)*. Human error is of particular relevance in maritime operations due to the unique characteristics of the work environment, and marine platforms have a high potential for maritime mishaps *(Bea, 2002, DiMattia et al., 2005)*.

Multiple studies have demonstrated that human error is one of the leading causes of accidents in the offshore industry complicated working settings *(Vinnem, 2014)*. The performance of the proper people is crucial to the success of offshore emergency operations. The success of offshore operations may be attributed partly to human factors, and by using the human factors principles in the design, development, and operation of offshore systems, it is possible to highlight this specific contribution *(DiMattia et al., 2005, Skogdalen et al., 2011)*.

Unpredictable emergencies in the procedures industries disrupt personnel and people, halting operations and inflicting environmental and physical damage. One of the most significant actions for enhancing people's readiness for natural and man-made catastrophes is learning the specifics of emergency evacuation and preparing for its execution. When emergency conditions arise on offshore platforms, it is better to begin evacuating personnel with all other activities if the possibility of damage caused by hazards is very high. The evacuation routes play a crucial role in structuring and expediting the evacuation procedures of offshore platforms *(Christian et al., 2009, Evans & Elphick, 2005)*.

Human factors play a significant role in errors, and numerous techniques have been developed to assess human errors. Jerry Williams proposed the HEART technique in England, and human reliability is assumed to be task-dependent *(Williams, 2015)*.

More than 25 personnel are now operating on Phase 2 and 3 oil platforms, which are among the most significant South Pars platforms in terms of exploitation and gas extraction capacity and on which the emergency evacuation procedures scenario was performed. Because the mentioned platform has the potential for gas leakage, fire, and explosion due to operation, which results in the announcement of the emergency of platform abandonment, it is required to look into and gauge the likelihood of human error during the emergency evacuation of the platform.

## METHODS

This cross-sectional study carried out on one of the South Pars gas platforms, and following an emergency maneuver, including a fire and explosion scenario, the HTA method was used to identify and separate actions linked to an emergency evacuation Figure 1. In the second stage of this study project, the HEART technique, introduced by Jerry Williams in 1985 and regarded as one of the ways of measuring human reliability, was used to evaluate the human error probability at each stage of an emergency evacuation. Based on the results, the probability of human errors happening at each stage of the gas platform emergency evacuation was assessed, and solutions were proposed to prevent their occurrence.

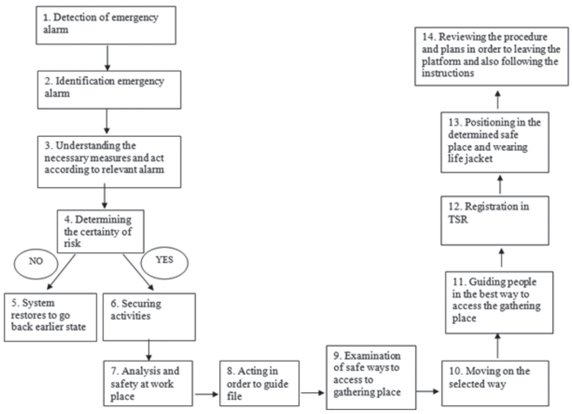


*Figure 1. Hierarchy of assembly activities in emergency situations in the offshore platform*

*Slika 1. Hijerarhija montažnih aktivnosti u izvanrednim situacijama na pomorskoj platformi*

## RESULTS

The tasks of the individuals in the emergency evacuation procedure in the fire and explosion scenario were established by the observations of the emergency maneuver and the evaluation of the authorized emergency response plan for the gas platform.

In the emergency response plan, the preparation of the people and the evaluation of the emergency evacuation procedures will begin after the platform residents have been gathered in their specific places. This plan contains four evacuation scenarios: evacuation by helicopter, by lifeboats installed on the platform, by life rafts deployed on the platform, and by boat or rescue float in the platform's area. According to the HTA method's findings, the scenario of evacuating individuals by helicopter consists of eight subtasks. The scenario of evacuating people by lifeboats put on the platform has eight subtasks, while the scenarios of evacuating people by life rafts placed on the platform and by boat or rescue float in the platform region each have six subtasks. Table 1 lists the various phases of an emergency evacuation.

**Table 1. Steps of the emergency evacuation procedures in the gas platform**

**Tablica 1. Koraci postupaka hitne evakuacije u plinskoj platformi**

| Emergency Evacuation Procedures | | |
|---|---|---|
| Evacuation of people by rescue helicopter | 1. Communicating with the pilot via the flight operator in the platform's control room | 5. Overview of recommendations, boarding strategy, and helicopter passenger safety to persons by safety officer or co-pilot |
| | 2. Guiding the helicopter when it is positioned on the platform's top helideck by the platform's flight control operator | 6. Ensuring that personnel utilize proper safety and rescue equipment, as determined by the safety officer or co-pilot |
| | 3. Checking and controlling the helicopter's indicators and equipment by the pilot | 7. Preparing the helicopter for takeoff by the co-pilot |
| | 4. Transferring individuals from the gathering point to the top helideck | 8. Taking off the helicopter and starting to fly |
| Evacuation of people by lifeboat | 1. Examining lifeboats cards and checklists to ensure their effectiveness | 5. Boarding personnel in lifeboats based on their capacity |
| | 2. Checking the capacity of each lifeboat | 6. Ensuring that personnel in lifeboats use proper safety and rescue equipment |
| | 3. Checking the place of throwing lifeboats into the water | 7. Turning on the boat and throwing it into the sea by the boat operator |
| | 4. General inspection by the safety officer or substitute of the recommendations and plan for boarding and safety of lifeboats for individuals | 8. Guiding lifeboats to the planned area according to the emergency response plan by the boat operator |

| | | |
|---|---|---|
| Evacuation of personnel by boat or rescue float in the platform area | 1. Communicating with rescue ships using the platform's control room, radio, or satellite systems to request help | 4. Connecting the platform's communication bridge to the rescue ship |
| | 2. Mooring of rescue ships as near to the platform's lowest level as possible | 5. The safety officer or a replacement directing the employees stationed at the gathering point to board the rescue ship |
| | 3. Communicating with the rescue ship to connect the communication bridge with the platform | 6. Moving the rescue ship away from the platform and making way to a secure place |
| Evacuation by life raft | 1. Examining life raft cards and checklists to ensure their efficacy | 4. Reviewing recommendations and life rafts boarding and safety plan to personnel by the safety officer or a substitute |
| | 2. Ensuring the stability and strength of the life rafts in an area of high resistance | 5. Throwing life rafts into the sea at the closest distance from the platform |
| | 3. Guiding personnel to the lower floors of the platform to be in the closest proximity to the distance of the life rafts | 6. Personnel jump into the water in groups of 5 and get on the life rafts and start paddling |

In this research, the HEART method was utilized to quantify the likelihood of human error during the emergency evacuation of an offshore platform. The probability of human error for helicopter evacuation stages is illustrated in Table 2, while the probability of human error for lifeboat-equipped platform evacuation steps is depicted in Table 3. The probability of human error throughout the stages of evacuating personnel using life rafts positioned on the platform and evacuating people using a boat or rescue float is detailed in tables 4 and 5, respectively.

**Table 2. Human error probability in the procedures of evacuating personnel by helicopter evacuation stages**

**Tablica 2. Vjerojatnost ljudske pogreške u postupcima evakuacije osoblja u fazama evakuacije helikopterom**

| Equipment for emergency evacuation | Emergency evacuation procedures | Human error probability |
|---|---|---|
| Evacuation of personnel by rescue helicopters | 1. Communicating with the pilot via the flight operator in the SPD3 platform's control room | 0.043 |
| | 2. Guiding the helicopter when it is positioned on the platform's top helideck by the platform's flight control operator | 0.152 |
| | 3. Checking and controlling the helicopter's indicators and equipment by the pilot | 0.216 |
| | 4. Transferring individuals from the gathering point to the top helideck | 0.022 |
| | 5. Overview of recommendations, boarding strategy, and helicopter passenger safety to persons by safety officer or co-pilot | 0.4 |
| | 6. Ensuring individuals utilize proper safety and rescue equipment, as determined by the safety officer or co-pilot | 0.043 |
| | 7. Preparing the helicopter for takeoff by the co-pilot | 0.391 |
| | 8. Taking off the helicopter and starting to fly | 0.021 |

**Table 3. Human error probability in the procedures of evacuating personnel by lifeboat installed on the platform**

**Tablica 3. Vjerojatnost ljudske pogreške u postupcima evakuacije osoblja čamcem za spašavanje instaliranim na platformi**

| Equipment for emergency evacuation | Emergency evacuation procedures | Human error probability |
|---|---|---|
| Evacuation of people by lifeboat | 1. Communicating with rescue ships using the platform's control room, radio, or satellite systems to request help | 0.261 |
| | 2. Mooring of rescue ships as near to the platform's lowest level as possible | 0.012 |
| | 3. Communicating with the rescue ship in order to connect the communication bridge with the platform | 0.024 |
| | 4. General inspection by the safety officer or substitute of the recommendations and plan for boarding and safety of lifeboats for individuals | 0.051 |
| | 5. Boarding personnel in lifeboats based on their capacity | 0.032 |
| | 6. Ensuring that personnel in lifeboats use proper safety and rescue equipment | 0.072 |
| | 7. Turning on the boat and throwing it into the sea by the boat operator | 0.43 |
| | 8. Guiding lifeboats to the planned area according to the emergency response plan by the boat operator | 0.165 |

**Table 4. Human error probability in the procedures of evacuating personnel by boat or rescue float in the platform area**

**Tablica 4. Vjerojatnost ljudske pogreške u postupcima evakuacije osoblja čamcem ili spasilačkim plovilom u području platforme**

| Equipment for emergency evacuation | Emergency evacuation procedures | Human error probability |
|---|---|---|
| Evacuation of personnel by boat or rescue float in the platform area | 1. Communicating with rescue ships using the platform's control room, radio, or satellite systems to request help | 0.275 |
| | 2. Mooring of rescue ships as near to the platform's lowest level as possible | 0.193 |
| | 3. Communicating with the rescue ship in order to connect the communication bridge with the platform | 0.071 |
| | 4. Connecting the platform's communication bridge to the rescue ship | 0.372 |
| | 5. The safety officer or a replacement directing the employees stationed at the gathering point to board the rescue ship | 0.015 |
| | 6. Moving the rescue ship away from the platform and making way to a secure place | 0.244 |

**Table 5. Human error probability in the procedures of evacuating personnel by life raft installed on the platform**

**Tablica 5. Vjerojatnost ljudske pogreške u postupcima evakuacije osoblja pomoću splavi za spašavanje postavljene na platformi**

| Equipment for emergency evacuation | Emergency evacuation procedures | Human error probability |
|---|---|---|
| Evacuation of personnel by life raft | 1. Examining life raft cards and checklists to ensure their efficacy | 0.261 |
| | 2. Ensuring the stability and strength of the life rafts in an area of high resistance | 0.044 |
| | 3. Guiding personnel to the lower floors of the platform to be in the closest proximity to the distance of the life rafts | 0.015 |
| | 4. Reviewing recommendations and life rafts boarding and safety plan to personnel by the safety officer or a substitute | 0.210 |
| | 5. Throwing life rafts into the sea at the closest distance from the platform | 0.122 |
| | 6. Personnel jump into the water in groups of 5 and get on the life rafts and start paddling | 0.016 |

According to human error probability evaluation tables, the largest probability rate is associated with steps 3 and 7 in the evacuation of personnel in emergencies by helicopter. In addition, the highest probability rate in the lifeboat evacuation scenario is associated with steps 7 and 1, respectively.

This study found that the highest rate of human error probability in the evacuation method by boat or rescue float is steps 4, 1, and 6. Steps 1 and 4 have the highest rate of boat or rescue float among the stages of evacuation by the rescue boat.

## DISCUSSION

The HEART technique was used in this study to assess the probability of human error during the offshore platform's emergency evacuation procedures. Human error is essential since it leads to unfavorable outcomes; consequently, it is required to predict, identify, and find its cause to prevent and limit the negative effects of human error. In the offshore industry, any error might result in accidents. Investigating human errors is particularly significant due to its critical involvement in catastrophic incidents, given its harmful nature and the complex and sensitive technology of offshore platforms. In an emergency, human error in any phase of the evacuation process can impede the entire process and increase the likelihood of significant casualties. It is compatible with Mehran Ghalehnovi's results about the evaluation of human error in the control room operators of petrochemical complexes *(Ghalenoei et al., 2009)*. According to the findings of the study by Deacon et al. *(2013)* the human error probability occurring during most emergency evacuation phases is significant.

The largest probability of error in emergency evacuation operations from the platform by helicopter is associated with the co-pilot prepping the helicopter for takeoff and flight and directing the helicopter from the platform's top helideck, according to the study's results. The emergency response of the platform has been specified in writing by the actions outlined in the execution plan. For the flawless and effective execution of evacuation operations and the departure from the platform, it is vital to follow the sequence of events outlined in this plan. Therefore, in this regard, formal and practical training courses for personnel working on the platform should be developed at each level of the hierarchical analysis. Due to the sensitive nature of the platform flight control operator's duties, it is advised that specialist training courses, such as HUET and HLO, be held, as well as the updating and notification of weather conditions to helicopter pilots and the installation of at least two helidecks on offshore platforms by international offshore platform standards. Regarding the incidence of human error when loading people into the helicopter, organizing monthly emergency evacuation maneuvers for personnel and analyzing the inadequacies of maneuvers is useful in preventing human error-related accidents.

This study revealed that turning on the boat and throwing it into the water, verifying the status of lifeboat checklists, and moving to the designated place according to the emergency response plan had the highest rate of emergency evacuation procedures in the case of lifeboat evacuation. These results' findings align with the study of Moshref et al. *(2013)*. In the scenario of evacuating and leaving the platform by boat or rescue ship in the vicinity of the platform, the procedures for connecting the communication bridge between the platform and the rescue ship, establishing communication through the control room of the platform or radio and satellite systems with the rescue ships in order to request evacuation, and moving the rescue ship away from the platform to a safe location had the highest probability of occurring among the stage procedures.

According to this study, checking life raft checklists, boarding them, and throwing them into the water when evacuating people with a lifeboat have the highest probability of human error. In this regard, weekly quality inspections of life raft equipment, the compilation of standard inspection checklists based on international standards, emergency landing courses on water, the release of life rafts, and the use of safety netting before jumping into the water are suggested.

Based on the nature of the fire and explosion scenario in the studied gas platform and the evaluation of the platform emergency evacuation methods, the safest method of evacuation during a fire is to evacuate people by lifeboat, evacuate people living on the platform with floats and rescue ships near the platform, and finally evacuate people by helicopter. It is not advised to guide a group of people into the water while using a life raft as a method of an emergency evacuation. This finding is consistent with the 2010 study on the risk assessment of the emergency evacuation of offshore platforms *(Deacon et al., 2013)*.

## CONCLUSION

According to the results of this study, monthly emergency evacuation maneuvers with respect to their feedback can be effective in reducing the risk of reaction in emergency evacuation. This study revealed that the level of training and performance of individuals during emergencies are directly related and that the high rate of human error in emergency evacuation procedures results from a poor and inadequate level of specialized training.

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# *VJEROJATNOST LJUDSKE POGREŠKE U POSTUPCIMA HITNE EVAKUACIJE S POMORSKIH PLATFORMI*

*SAŽETAK: Studija ima za cilj utvrditi vjerojatnost ljudske pogreške tijekom hitnih evakuacija s pomorskih platformi pomoću HEART metode. Nakon izvođenja hitnog manevra u situaciji požara i eksplozije, korištena je HTA metoda kako bi se utvrdile i razdvojile hitne evakuacijske radnje, a HEART metoda korištena je za procjenu vjerojatnosti ljudske pogreške. Na kraju, predložene su prikladne kontrolne mjere temeljene na nalazima. U slučaju požara i eksplozije, najsigurniji načini evakuiranja ljudi s pratforme su pomoću čamca za spašavanje, zatim spasilačkim splavima i obližnjim brodovima za spašavanje te evakuacija helikopterom. Zbog iznimno visokog rizika, ne preporuča se korištenje plutača niti skakanje u vodu. Savjetuje se ispitati stanje sigurnosti na platformi, organizirati specijaliziranu poduku i tjedne vježbe za osoblje zaduženo za hitne evakuacijske procedure na platformi te praćenje, popravak, održavanje i inspekcija opreme.*

***Key words:*** *ljudska pogreška, pomorske platforme, hitna evakuacija*

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