HSE Engineering of Unmanned Wellhead Platforms

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Recent developments show that there is an increased interest by Oil and Gas Companies in Unmanned Wellhead Platforms (UWPs) as an alternative to manned offshore installations in shallow waters. The main driver in the Dutch and UK sector is the cost-effective development of small fields which are not economically viable in case a manned installation option is chosen. This paper provides an overview of the latest developments for UWPs from a HSE and availability point of view based on the HSE engineering support experience of the authors in the Netherlands. UWPs provide benefits and challenges with respect Health, Safety and Environmental (HSE) aspects, as well as from an availability point of view. UWPs come in a variety of forms such as monopile or jacket type, with or without a helideck, boat access or walk-to-work systems, etc. What HSE related challenges does one face during the design UWPs? The pros and cons of various design options are discussed in this paper. An important challenge of designing an UWP is to ensure safe evacuation or escape from the installation. The relatively small dimensions of the UWP make it important to ensure that personnel are shielded against heat radiation exposure. When using walk-to-work systems one should assess the possible impact of fire and explosion on these systems and the service operation vessel (SOV). Alternative escape routes such as direct entry to sea and throw-over life rafts are possible alternatives when the primary evacuation is not available. The amount of personnel on-board, maintenance intervals, ease of use and time required to evacuate or escape are all factors that must be taken into account when selecting the appropriate type of safety equipment. Another challenge is the ability to remotely operate the UWP versus the need for maintenance. Ease of mechanical handling at UWP installations is also important to limit the time on board of visiting personnel.

Keywords: HSE Engineering, Technical Safety, Normally Unmanned Installations, NUI

Introduction

Normally Unmanned Installations (NUI) have been installed around the world since the 1970s. In the Gulf of Mexico, a large number of minimum facility platform designs were adopted in the 1970s and 1980s to exploit marginal fields. As the North Sea industry matured in the 1990s, minimum facility platforms gained favor as flow assurance improved and as the need to minimize capital expense for marginal fields was acknowledged [SPE, 2015]. Recent developments have increased the interest of Oil and Gas Companies in NUIs. The main driver in the Dutch and UK sector is the cost-effective development of small fields which are not economically viable in case a manned installation option is chosen [Metcalf, 1993]. There is no one uniform definition for a NUI and thus these types of installations come in different varieties such as:

- Installations that were initially permanently manned but have become unmanned e.g. due to remote operation or awaiting decommissioning at a later time;
- installation that are occasionally manned, with or without overnight stays;
- Installations that have a low frequency of planned visits per year (e.g. < 1 per 6 months) with no overnight stays.

In this paper we define a NUI with a low visit frequency, minimum facilities on-board, no option for overnight stay on the installation and located in shallow water as an "Unmanned Wellhead Platform" (UWP). Oil or gas is produced on the installation and transported through a pipeline to another (manned) installation or to an onshore location for further processing. The basic assumption is that visits are only required for routine inspection or planned maintenance. This paper provides an overview of the latest developments for UWPs from an HSE and availability point of view based on the HSE engineering support experience of the authors in the Netherlands.

During concept selection there are various choices to be made for the UWP that each have their own advantages and disadvantages. In this paper an overview of the various options are presented and points of attention with respect to Health, Safety and Environment discussed which are relevant for modern UWPs.

Marine Access and Transfer

The primary evacuation philosophy, which will be discussed later, depends on the choice of transfer and access to the UWP. Helicopter access has the advantage that the installation is relatively quickly reached if located nearby a larger installation or shore location with helicopter transport capabilities. Since the UWP concept assumes that no provisions for overnight stay are in place, the helicopter access option for an UWP has several disadvantages:

- A helideck and associated systems require regular maintenance and inspection;
- In case of a prolonged visit, an increased number of helicopter flights are required to and from the installation.

It is for the above stated reasons that marine transfer by boat is usually the preferred method for an UWP. Marine access in the Netherlands is performed either by launching a small boat, usually a fast rescue craft (FRC), from an attending service operation vessel and letting personnel board the UWP at the boat landing access area or using "Walk-to-Work" (W2W) type systems. The fact that personnel are transferred by service operation vessel and remain on the service operation vessel for overnight stays means that potential for sea sickness needs to be taken into account when selecting and training personnel who are going to work on an UWP. It is likely that only specially trained operators will be able to visit the UWP.

An alternative to the boat landing is a W2W system. A W2W system works by using a motion compensated gangway installed at a service operation vessel and connecting it to a point on the installation, allowing personnel to walk from one to the other. These W2W systems have been in use in the Dutch and UK North Sea since 2006, but initially marine access was performed by boat landing access before the use of W2W systems become more commonplace. The advantage of the W2W systems is that the installation can be accessed without having to transfer by fast rescue craft to the installation. Embarkation by fast rescue craft to a ladder from the water surface can be challenging depending on the sea state. W2W systems are motioned compensated systems and thus allow easier transfer between a service operation vessel and the installation. Some points need to be taken into consideration with respect to marine transfer and access when using these systems:

- The sea state at which these W2W systems can operate will determine how often installations can be visited for maintenance;
- Transfer by W2W connection to an UWP carries the risk that personnel may fall off, get caught between the gangway and installation, etc. It should be considered that personnel wear life jackets and/or and immersion suits while crossing the gangway;
- Performing quantitative risk analysis on W2W systems is challenging due to a lack of failure rate date for these systems;
- It should be decided where the service operation vessel will be positioned after personnel transfer using the W2W system. This will depend on the primary evacuation philosophy adopted for the installation.

To summarize: W2W systems are increasingly used for visiting UWPs and are slowly becoming the preferred option for marine access. There are some specific points that need to be taken into account when deciding to use a W2W system such as safety during transfer and positioning of the service operation vessel when personnel have boarded the installation.

Evacuation and Escape

One of the most important philosophies during the design of the UWP is the evacuation and escape philosophy. By evacuation it is meant that personnel use the primary means to leave an installation such as a helicopter, Free Fall Life Boat (FFLB) or Totally Enclosed Motor Propelled Survival Craft (TEMPSC) [OGP, 2010]. By escape it is meant that secondary or tertiary means are used to leave an installation such as using ladders, stairs, chutes, personal descenders, davit launched life rafts, or uncontrollably by jumping.

Primary Means

Helicopter evacuation is not always possible during an emergency. The reason for this is the time required for the helicopter to reach the installation during emergency as well as possible difficulties to reach the installation during a fire. Especially in the case of an UWP, where the intent is to not install a helideck, another primary route for evacuation will have to be chosen and designed for. A lifeboat, FFLB or TEMPSC, could be an option but evacuating using this method requires that a lifeboat must be installed on the installation with accompanied frequent inspection and maintenance. This usually conflicts with the attendance philosophy of the UWP and therefore other methods for primary evacuation are usually considered during the design of an UWP. While the early UWPs in the Dutch and UK sector adopted the boat landing access approach, nowadays more and more UWPs are accessed by W2W systems and use this as their primary means of evacuation. The use of this system as a primary evacuation route will be further discussed in the paragraph.

There are three options that can be considered when using the W2W system as a means for access and primary evacuation:

1) Batch transfer of personnel and repositioning of the service operation vessel at a distance within 500 meters from the installation;
2) Semi-continuous access;
3) Continuous access.

Option 1 is the conventional means of transfer for using a W2W gangway system. The advantage of this option is that it is regularly used in the field, there is a reduced probability of ship or gangway collision compared to the other options and that the service operation vessel is less exposed to hazards from the installation. The disadvantage of this option is that personnel will have to wait for the service operation vessel to reposition itself and have the gangway connected before being able to evacuate. When the W2W system is disconnected and the service operation vessel moves away from the installation, the time it takes to return and reconnect the gangway should be taken into account in the evacuation time when performing an evacuation assessment. One W2W gangway system vendor estimated that it takes between 1 and 2 minutes to have the gangway ready for transfer of personnel from the moment an alarm arrives. This is excluding the time it takes for the service operation vessel to position itself alongside the UWP. The longer it takes for a vessel to reposition itself and connect the gangway, the more stringent the protection requirements on the muster area near the gangway access area on the UWP will potentially have to be to protect personnel from hazards such as heat radiation from a fire.

Option 2 is an alternative to moving the service operation vessel away from the installation by having the service operation vessel remain nearby the installation with the gangway aimed towards the gangway landing area. The gangway retracts far enough to the point that the Dynamic Positioning (DP) footprint will not accidentally press the gangway against the installation. In case of an emergency, the gangway can be extended relatively quickly. According to a vendor it would take approximately 20-30 seconds to be ready for transfer after an alarm arrived. The advantage is that the service operation vessel does not need to reposition itself, thus facilitating a quicker evacuation of personnel during an emergency compared to option 1. The disadvantage of this method is that the proximity of the service operation vessel increases the risk of ship or gangway collision and leaves the vessel more exposed to hazards from the installation.

Option 3 is an option that is being considered in some recent UWP designs but to the knowledge of the author has not yet been applied in the field. It assumes a continuous connection of the W2W gangway with the UWP as long as personnel remain on-board of the installation. This option could be considered if it is anticipated that extensive 24/7 maintenance operations are required on the installation without the presence of another vessel such as a bridge connected drilling rig. The advantage of this method is that it lowers the evacuation time from the installation compared to the other options. But having the gangway continuously attached also poses some challenges:

1. At this point in time there are very little, if at all, W2W systems used in offshore applications that are designed for continuous operations. Should a currently on the market available W2W system be used in this manner than, according to a vendor, it is estimated that the gangway will need to be disconnected at least once a day for an hour or two for preventive maintenance;

2. Failure rate data of continuous access systems are limited available at best for these type of systems, making QRA comparison and availability assessments between options challenging;

3. The close proximity of the service operation vessel could expose it to hazards from the installation. Jet fires directed towards the service operation vessel could expose it to high heat radiation intensities. When personnel from the installation evacuate to the Temporary Refuge (TR) on the service operation vessel, exposure to heat loads on the evacuation route of the service operation vessel should also be taken into account in the hazard assessment. If the service operation vessel remains close to the installation than hazards from the installation to the service operation vessel should be taken into account during risk assessments such as jet fires, explosion, dropped objects and swinging loads;

4. As was the case in option 2, the service operation vessel can pose a risk to the installation due to its proximity. A loss of position scenario of the service operation vessel while the gangway is extended could damage the gangway and carry the risk of impact with process equipment. Preferably this should be taken into consideration when designing the landing area for the W2W system such as choosing a gangway landing area with minimal process facilities in the vicinity and considering shielding of process equipment in proximity of the gangway connection.

Currently option 1 is the most used method for evacuation when a W2W system is used. Depending on the time it takes for a service operation vessel to position itself along the installation, option 2 might be an interesting one to assess as an alternative to option 1 since it could reduce the evacuation time of personnel from the installation. Should this option be chosen, it should be assessed if additional protection around the gangway landing area on the installation is required in case of a loss of position scenario of the service operation vessel or operating error of the gangway. Option 3 could be considered when it is expected that extensive 24/7 operations are required but there is still little experience in the field using the gangway systems continuously and thus it must be discussed with the W2W system vendors during the early stages of an UWP design how viable this option is.

Secondary and Tertiary Means

The interpretation of what is regarded as a secondary means of escape for UWPs differs between some oil and gas operators. The choice usually depends on how the secondary escape is defined in the oil and gas operator standards or national regulations. Some state that the secondary means of escape can be equal to the primary means of evacuation providing it is always available, has sufficient capacity so that it is capable of dealing with the full complement of the installation in a controlled manner without undue delay. Others define helicopter winching as the secondary escape for non-emergency cases such as medical transport. In this case the CAP 437 [CAA, 2013] is commonly used a reference for the design of a helicopter winching area. The winching area should have enough clearance depending on the helicopter used and restrictions are defined for height and presence of objects within the manoeuvring zone. Adequate space reservation is required on the installation should helicopter winching be considered as a secondary means of leaving the installation.

Should the primary means of evacuation and the secondary means of escape be unavailable, an additional escape must be available. The following options for this tertiary means of escape can be considered:

- Ladders to sea;
- Personal descenders to sea;
- Ladders or personal descenders in combination with throw-over life rafts;
- Escape chutes.

Ladders to Sea

Ladders to sea are the easiest tertiary means of escape. Personnel descend down the ladders and either wait for pick-up by an attending fast rescue craft or enter the sea and wait for pick-up there. The advantage is that no training is required and provided that there is a good maintenance regime, there is high probability of the system being available, assuming that the ladders are also protected against major hazards. In addition, the ladders provide a reference point for the FRCs to navigate to during an emergency. Since the ladders are located at a fixed location, it is easier to ensure that suitable evacuation equipment such as life jackets and immersion suits are available near the point where personnel will escape to sea. The disadvantage of this system is that there is a risk of falling from the ladders and that personnel have to enter the sea to escape from the installation if the FRC is not able to moor along the ladder. Fall risk can be reduced by installing a fall protection system and using fall protection devices. The more personnel there are on the installation, the longer it takes to recover them from the water with the risk that personnel will drift away from the facility. One could consider designing an access platform for personnel to wait for pick-up without entering the sea but this has several disadvantages. The most important one is that personnel are exposed to the sea waves at the access platform and might be thrown of the facility. Secondly there is the practical matter of robustly designing the platform in order to have it available all year round. Thirdly, boarding a FRC from a ladder directly is only possible at low sea states, 1.5 meter significant wave height is currently adopted as a guideline. If it is not the intention that personnel enter the sea directly but board by ladders, than this would pose additional operation restrictions to how often and when the UWP can be visited. Finally, marine growth and guano can build-up on the ladders and can have an adverse effect on the safety of personnel when escaping. This marine growth and guano should be removed prior to access.

Personal Descenders to Sea

Personal descenders come in various types but when used without a life raft these descenders are based on an easy ‘abseiling’ method in which the users strap themselves into a harness before lowering over the side of the installation. They can control the speed of descent by means of a braking mechanism. When not connected to a guided painter line of a life raft, the person who is descending can lock the device above the sea, remaining visible and more importantly dry, while waiting for rescue with an FRC from a supporting operation vessel. Depending on the weather conditions the person will swing, therefore the preferred descending locations should be analysed carefully that it is not or hardly possible to swing against the platform structure. The personal descender can be attached to a handrail or other load bearing structure. Descending from the platform down to sea level is a slow process which is manually controlled by the person who is descending.

The disadvantages of this system are:

- Is more complex to use compared with ladders;
- Personal descenders requires additional training for personnel;
- Has a larger scope for error in use during emergency conditions;
- Not quite so quick to use as a ladder although speed is unaffected by number of persons escaping;
- Potentially more doubt about location of escapees in the sea and their descending point;

In addition the personal descending equipment needs to be brought aboard by personnel or stored on the installation. Should personnel descenders be used it is recommended to have some areas designated as descending areas and have the hand railing strengthen at those points in combination with a gate system to avoid personnel having to climb over the rail to descend.

Ladders or personal descenders in combination with throw-over life rafts

The use of life rafts allows personnel to wait for escape inside the rafts and have the option to move away from the installation in case it is deemed required. Throw-over life rafts can be stored almost anywhere on racks, railings and ramps, saving valuable deck space. They are packed in rigid fibre-glass containers that make them especially durable and resistant to water ingress. The life raft retaining strap must be capable of being quickly and easily released and the life raft is physically thrown over the side. When the life raft enters the sea, the painter line is then pulled to inflate the life raft. This painter line remains connected with the installation and the life raft to ensure that the life raft is not drifting away from the installation. Throw-over life rafts can be used in combination with personal descenders. Personal descenders have been designed to assist an escape to a life raft by incorporating a strop, which is attached to the life raft painter line prior to descent. The painter line acts as a guide, during descent, for easy entry into the life raft. The escapee remains safely attached to the descending device with the painter line throughout this operation alleviating the risk of being washed away when entering the sea. When the deployed life raft remains in close proximity to the installation it is possible to enter it directly using the personal descender. Ladders can also be used to access the throw-over life rafts but it is usually necessary to enter the sea first and from there board the life raft. Contrary to the personal descenders, this will have to be done without a painter line thus increasing the risk of being washed away when entering the sea.

Using life rafts has the advantage that personnel can await recovery inside the life raft instead of in the sea. The disadvantage of this system is that these systems require maintenance if installed permanently. Temporarily installing the life rafts can be an option but mechanical handling of these systems and the time required for installation and removal would have to be considered. In addition one would have to assess if it is allowed to have personnel on-board the installation when the temporary life rafts are not yet installed.

Escape chutes

Escape chutes are essentially systems that utilises a telescopic chute with integrated life rafts and are outfitted with a controlled launching and recovery mechanism. When not in use, all components of this system are stored inside the interface structure. They are extensively used on installations in the Norwegian Continental Shelf of the North Sea on manned installations. They are easy to use and relatively quick to deploy. The disadvantages of these systems are that they are usually large, relatively heavy, require significant annual maintenance and are fixed to one location. This is the main reason why they are not the first choice in the UK and Dutch sector for UWPs. Temporary installing such a system could be considered as an option to mitigate the offshore maintenance and inspection requirements but there is very little known experience in using escape chutes in this manner. The risks of damaging the chute during installation and removal should be properly mitigated in case the system is to be temporarily installed.

Summary of escape methods

Balancing between maintenance requirements and ease of use is a key factor in choosing one of the above systems for evacuation or escape. Temporary installed systems could be attractive from a maintenance point of view since inspection and maintenance of these systems can be done onshore. Should a temporary escape chute system be available that is easily and quickly installed and removed than it could be an attractive tertiary means of escape option for an UWP. Currently, these systems are not used in this manner since they require permanent installation. It depends on the maintenance requirements and philosophy of the facility if a permanently installed chute is an acceptable option. Temporary installed throw-over life rafts in combination with personal descenders are an alternative to the chute system since the life rafts can be more easily installed and removed than a chute system but using personal descenders requires additional training for personnel. Permanently installing life rafts requires more offshore inspection and maintenance and it depends on how frequent an UWP will be visited if this is a desired option. Descending to sea using personnel descenders is a tertiary means of escape method that could be considered if there are a very limited number of personnel intended to be present on the installation, FRCs are on close standby to pick-up personnel and if the philosophy is such that visits to the installation are only performed during good weather conditions. Ladders to sea are a last available option.

Safety Equipment

The safety equipment required on the installation will depend on the hazards of the installation and the evacuation and escape philosophy. Safety equipment in this paper is defined as fire extinguishers, immersion suits, life jackets, personal descenders, etc. Current common practice in the North Sea is that as less as possible of these systems are permanently installed on the unmanned installations. Fire extinguishers are broad on-board by visiting personnel and placed at strategic locations on the installations. Immersion suits, life jackets and personal descenders are in some cases stored at a fixed location on the installation for the duration of the visit and return with personnel when they leave the installation. Early philosophies of UWPs in the Dutch sector considered having personnel choose to keep their immersions suits on during maintenance visits in order to minimize storage space requirements on the installation. This proved to be impractical since it would make working on the installation more difficult for personnel. From a practical point of view the life buoys are preferred to be permanently installed since they require little maintenance.

Fire and Gas Detection Coverage

A challenging aspect in the design of an UWP is to find a balance between the amount of detectors for sufficient detection coverage, redundancy and the frequency of required maintenance on these systems. The design goal is to limit the amount of unplanned maintenance visits as much as possible. One wants to avoid that a failure of a single detector would cause a blind spot on the facility since this would impair the safety critical function of the fire and gas (F&G) detection system and necessitate a maintenance visit. Redundancy in area coverage could help mitigate this in combination with having secondary detection system based on a different detection principle (for example: point gas detection versus acoustic detection).

Environmental Aspects

The prevention or minimisation of discharges to sea and emissions needs to be considered during the design. Some UWPs use renewable energy sources such as windmills and solar cells as their power supply since the installation has a low energy consumption.

One environmental item that is especially relevant on unmanned installations is the ability to detect a spill. On some installations in the North Sea cameras are placed at strategic location on the installation which are monitored from a remote facility in order to detect spills.

Miscellaneous Aspects

In the UK and in the Netherlands some UWPs are of a monopile type. Monopile installations are fixed to a single pile as opposed to jacket installations. The advantage of a monopile concept is that the amount of steel required is less compared to a jacket platform and thus beneficial from a CAPEX point of view. One of the important HSE points of attention is that it should be ensured that welded connections are used for risers inside the monopile to reduce the probability of leakage inside the pile. In case there is a risk of a spill of a hydrocarbon liquid on the topside of the installation it should be ensured that the liquid cannot accumulate inside the monopile. An unignited spill inside the monopile could result in the build-up of hydrocarbon gas resulting in an explosion when ignited. Should the oil be ignited, the fire could impair the monopile due to loss of its lead bearing capacity due to heat-up of structural steel.

The drive to reduce equipment on-board of an UWP leads to the question about whether a fixed platform crane should be installed on an UWP. The benefit from a maintenance and CAPEX point of view by having no fixed crane should be weighed against the additional time and risk of having to install equipment with another vessel or Rig.

As marine access is adopted for the UWP concept the possibility for rapid intervention in case of equipment or system failures depends on the actual weather conditions. Furthermore considering the unmanned nature of the UWP, repair times for equipment on the UWP may increase due to the additional mobilisation times. Therefore consideration should be given during design to production availability and the reliability of equipment used for the UWP.

Conclusion and Summary

In this paper various options were presented and points of attention discussed with respect to Health, Safety and Environment specific for an UWP based on engineering experience in the Dutch and UK sector. W2W systems are increasingly used for visiting UWPs and are slowly becoming the preferred option for marine access. There are some specific points that need to be taken into account when deciding to use a W2W system such as safety during transfer and the positioning of the service operation vessel when personnel have boarded the installation.

The interpretation of what is regarded as a secondary means of escape for UWPs differs between some oil and gas operators. Some state that the secondary means of escape can be equal to the primary means of evacuation providing it is always available, has sufficient capacity so that it is capable of dealing with the full complement of the installation in a controlled manner without undue delay. Others define helicopter winching as the secondary means of escape for non-emergency cases such as medical transport. Should the primary and secondary means of evacuation or escape be unavailable, escape direct to sea or with a life raft is required. Balancing between maintenance requirements and ease of use is a key factor in choosing one of the above systems for escape. Temporary installed systems could be attractive from a maintenance point of view since inspection and maintenance of these systems can be done onshore.

Current common practice in the North Sea is that as less as possible safety equipment is permanently installed on the unmanned installations to reduce the need for maintenance. Personnel will bring most of the equipment on-board during a visit. Fire and gas detection redundancy in area coverage will reduce the amount of maintenance visits required to the installation should one of the detectors fail. The use of renewable energies on a UWP can be considered due to low power consumption.

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