Assessment and Enactment of Response to Severe Weather Hazards to Offshore Structures

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The traditional approach to designing offshore structures in line with codes was to use the magnitude of an extreme wave as input to the selection of the deck height of offshore structures, as well as using it in the assessment of the response to extreme weather events. As the study of extreme weather hazards has improved over the years, the expected design wave height has increased, meaning that facilities designed to earlier versions of the code may have a higher risk from structural hazards than originally thought. As well, advances in meteorological modelling has meant that it is now possible to predict the progress of major storms sufficiently well in advance to determine location-specific risks and enable timely response to reduce the risk to personnel on-board the facilities.

With some of the facilities in the worldwide oil and gas industry over 40 years old, and with some facilities with reduced structural strengths due to defects, there is an increased risk of a severe weather event resulting in a significant major accident. If this is not considered in sufficient detail in advance, the level of risk may be higher than acceptable limits set out in operators safety cases, but without full consideration of the risks, any possible mitigation, and detailed planning for how to respond in severe weather mode, this risk may be being inadvertently accepted.

The risk decision is unlike other major accident hazard risks, as the predictive capability of the modern modelling allows the timing of the risk to be understood and gives sufficient safety time for a meaningful response. The paper will present a process safety view of the hazard using detailed input from the structural engineering specialists and outline how to assess and mitigate the risks of extreme weather in a range of operating basins including the North Sea, Australia, and the Gulf of Mexico.

Introduction

The traditional approach to designing offshore structures in line with codes was to use the magnitude of an extreme wave as input to the selection of the deck height of offshore structures, as well as using it in the assessment of the response to extreme weather events. As the study of extreme weather hazards has improved over the years, the expected design wave height has increased, meaning that facilities designed to earlier versions of the code may have a higher risk from structural hazards than originally thought. As well, advances in meteorological modelling has meant that it is now possible to predict the progress of major storms sufficiently well in advance to determine location-specific risks and enable timely response to reduce the risk to personnel on-board the facilities.

With some of the facilities in the worldwide oil and gas industry over 40 years old, and with some facilities with reduced structural strengths due to defects, there is an increased risk of a severe weather event resulting in a significant major accident. If this is not considered in sufficient detail in advance, the level of risk may be higher than acceptable limits set out in operators safety cases, but without full consideration of the risks, any possible mitigation, and detailed planning for how to respond in severe weather mode, this risk may be being inadvertently accepted. It should be noted that this is not to say that there is particularly an increased frequency or intensity of storms e.g. the scientific community does not appear to have reached consensus on the change in magnitude due to climate change effects and if we will necessarily see such a change for storms. However, it is fair to say the metocean data quality and forecast predictions have improved to the extent that we can now calculate the level of storm risk when a storm is forecast, which was not possible at the time when many platforms were designed.

This risk decision is unlike other major accident hazard risks, e.g. loss of hydrocarbon containment, as the predictive capability of modern modelling allows the timing of the risk to be better understood in comparison to the other hazards and gives sufficient safety time for a meaningful response. The paper presents a process safety view of the hazard using detailed input from the structural engineering specialists and outline how to assess and mitigate the risks of extreme weather in a range of operating basins including the North Sea, Australia, and the Gulf of Mexico.

This paper outlines the historical, annualised approach to quantifying the risk to personnel from extreme storms and then postulates a proposed future approach, taking into consideration the elevated risk that personnel are exposed to when an actual storm is forecast since this type of hazard is different to most others in the offshore environment. For events with little or no warning such as sudden storms, seismic loading or loss of hydrocarbon containment, managing life safety based on an annualised risk is appropriate. However, for events such as a severe storm that can be predicted days in advance, before it reaches a location, the risk to personnel can be reduced by removing them from the facility or better known as de-staffing the facility. This is common practice in the Gulf of Mexico, where for significant hurricanes that develop in the Atlantic Ocean and track towards the Gulf of Mexico, facilities are de-staffing.

Background

Although the occurrence of jacket failure while crew are on board is rare, there has been a significant number of facilities significantly damaged or collapsed that were de-staffed in the Gulf of Mexico. This includes 45 platforms in hurricane Katrina, 56 platforms in hurricane Rita and 50 platforms in hurricane Ike that all occurred in the past 20yrs (US Dept of IMMSER). Since there are a larger number of facilities in the Gulf of Mexico, the likelihood of a rogue wave impacting one of these platforms is greater. This, in combination with the increase in the design waves for the region, is likely to be the reason for a higher number of incidents. For regions with less facilities such as Australia or the North Sea there has only been a small number of these failures but as the codes used for design are similar for all regions the risk within a storm per facility would be the same.

Furthermore, a review of the Oil & Gas disasters shows that extreme storms played a part in 7 of the 10 worst worldwide Oil & Gas disasters, in terms of number of fatalities from the Alexander Kielland in 1980 to the Usumacinta Jack-up in 2007.

Wave and Storm Nomenclature

To understand the risk from extreme storms it is important to note the following definitions:

Hc	Crest Height i.e. the point on a wave with the maximum value of upward displacement above still water level within a cycle.
Trough	Minimum point on a wave within a cycle.
Wave Height	Trough to Crest.
Hs	Significant Wave Height. The mean of top 1/3rd of wave heights within a sea state.
MPM	Most Probable Maximum predicted wave height for a sea state. Generally, around 1.6 to 1.9 x Hs.
RP	Return Period
Rogue Wave	An abnormal wave height within a sea state, occasionally seen but in excess of 2 x Hs.
Short-term Distribution	The distribution of the maximum wave (heights or crests) within a single sea state of a given duration in the order of hours.
Long-term Distribution	The distribution of exceeding a sea states (e.g. Hs) over a number of years.
Down-staffing	The evacuation of non-essential personnel from a facility, keeping core crew on board (formerly known as 'down-manning').
De-staffing	The final evacuation of the last remaining personnel from a facility.

Long-term and Short-term Distributions for Storms

Fixed platform structural designs are governed by the loading of a single extreme wave. The calculation of the annual probability of failure while the platform is staffed requires an understanding of the long-term significant wave height statistics and the conditional short-term maximum wave height statistics within a storm. The long-term annual statistics describe the probability of a storm exceeding a given threshold per year. The short-term statistics enable calculation of the failure probability if a storm of a given magnitude occurs and are derived from a knowledge of the platform capacity, the storm intensity, storm duration, current and wind load.

Long-Term Distribution of Storms

Figure 1 shows a long-term distribution of storm peak Hs. This figure is developed by fitting a distribution to the recorded storms (or Hs) for a particular location over the long term, typically 30-50 years and extrapolated to much longer return periods. The annual probability of exceedance of an event with return period (RP) is calculated by 1-exp(-1/RP). Thus, an Hs of 15 m with a RP of 100 years has an annual probability of exceedance of 0.01 and an Hs of 11 m with a RP of 10 years has an annual probability of exceedance of 0.095.

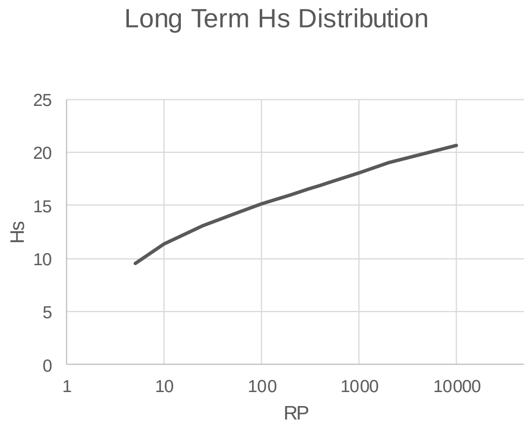

Figure 1. Long-Term Hs Distribution

Short-Term Distribution

A storm (Figure 2) is defined to be a single event with a peak sea-state intensity, Hs, that exceeds a threshold value that is selected to ensure that each storm is independent. Typically, the Hs threshold for the UK North Sea is taken to be around 5m. A single storm is then represented by a number of sea-states of fixed duration that increase over time to the peak before reducing.

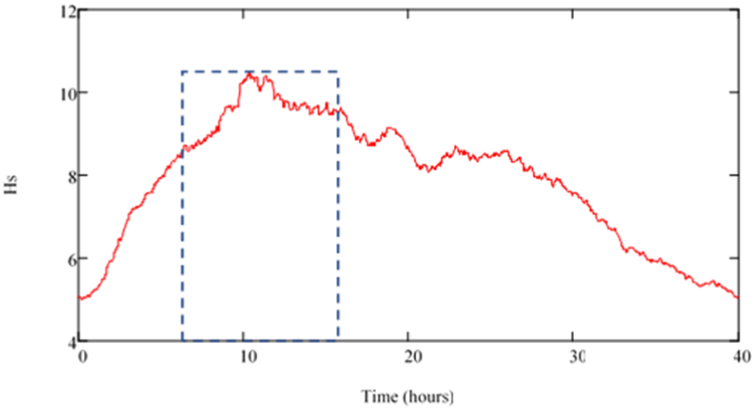

Figure 2 **Typical storm profile and equivalent rectangular storm**

The statistics of wave-height or crest height within a single sea-state are called the short-term statistics and are conditional on the sea-state intensity, Hs. Although each storm profile is different, we can typically represent a storm as an equivalent rectangular storm with an Hs value equal to the storm peak and a duration T, less than the real storm duration, such that the statistics of the real storm match those of the equivalent storm.

The individual wave height (H) cumulative distribution within a sea-state of constant intensity Hs can be represented by the Forristall distribution (Forristall, 1978):

$$P_{Forristall}(H \mid H_s) = 1 - \exp\left(-\left(\frac{H}{\alpha H_s}\right)^{\beta}\right) \tag{1}$$

Forristall recommends α = 0.681 and β = 2.126 based on buoy data from the Mexican Gulf, but these values have been found to have a more general applicability. There is ongoing research in the area of short term statistics which may result in slightly different distributions, but the overall methodology presented in this paper will still be valid.

For a single sea-state of duration T and zero crossing period Tz, the number of waves is Nwaves = T/Tz, and the short-term cumulative distribution of the largest wave height is given by:

$$P_{H_{\max Sea}}(H_{\max} \mid H_s) = P_{Forristall}(H_{\max} \mid H_s)^{N_{waves}} \tag{2}$$

Considering all sea-states in a storm, the cumulative distribution function for Hmax is:

$$P_{H_{\max} Storm}(H_{\max}) = \prod_{i}^{n_{seastates}} P_{Forristall}(H_{\max} \mid H_{s_i})^{N_{waves\ i}} \tag{3}$$

If we now consider a rectangular storm comprising a single sea-state with Hs equal to the peak of the real storm, we can equate equations (2) and (3) to determine the number of waves in the equivalent rectangular storm and its duration, given by T = Nwaves * Tz. From consideration of many storms in the UK North Sea it has been found that the average duration T of an equivalent rectangular storm is approximately 10 hours to represent the true storm which has a varying intensity over a much longer duration than 10 hours.

Figure 3 shows the maximum wave-height statistics for an actual storm and an equivalent storm. It is seen that there is a very good agreement, and this is consistently the case for a typical storm, irrespective of their profile.

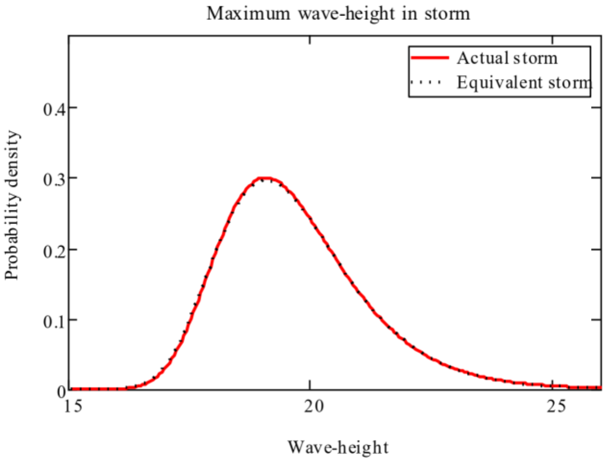

Figure 3 Comparison of Maximum Wave Height in Actual Storm with Equivalent Rectangular Storm

Historical Approach - Annualised Collapse Risk vs Risk in a Storm

Historically, the annual collapse risk associated with offshore structures, designed in accordance with modern standards, has been typically in the range of 10^{-5} to 10^{-3} and this has been appropriate for inclusion within the Quantitative Risk Assessment (QRA) that have been developed for most offshore installations. The safety factors vary for each region depending on the slope of the hazard curve to ensure the annual risk is maintained. Depending on the structure's life safety category and consequence category, the overall exposure level (L1, L2 and L3 as outlined in ISO19900) allows for variations in the annual risk, however it is still within the range above.

The calculation of annual risk of an offshore structure collapse due to severe weather is the combination of the environmental hazard curve and the structural capacity range or fragility curve. As mentioned earlier, the environmental hazard curve associated with wave loading is derived from a combination of the extreme value calculation for significant wave height, known as the long-term sea state distribution, with the variation in possible maximum wave height within each sea state, known as the short-term distribution. Based on this approach wave heights associated with annual risk or return period are determined, as shown in Figure 4. For an L1 structure which is 'manned non-evacuated' and 'high consequence' of failure the critical wave height that would lead to collapse typically has an annual risk of 10-4 or return period of 1 in 10,000yrs.

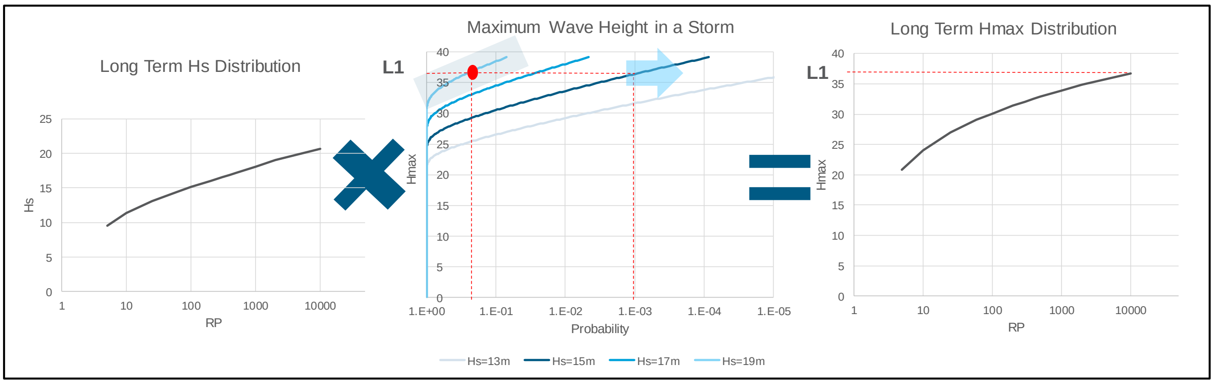

Figure 4 Combination of Long Term Hs Distribution and Short Term Probability of Maximum Wave

However, when a storm is forecast, the significant wave height is predicted for a range of time into the future. These storms will normally increase over a period of time, have a short duration at the peak significant wave height and then reduce with the total storm duration ranging from 24 to 48 hrs. Using the same variation in maximum wave heights, which in this case is based on the Forristall distribution (Forristall, 1978), within the sea states that are forecast during the storm, then the probability of the maximum single wave for the approaching storm can be calculated.

This is where the approach differs from the historical annualised approach i.e. once a storm has been forecast then the risk to personnel is known to be at a significantly elevated level in comparison to the annualised risk included within the QRA. The same cannot be said for most other major accident hazards e.g. it would be difficult, if not impossible, to predict the timing of a loss of hydrocarbon containment event which is a more random event at point of occurrence. Perhaps the most equivalent predicted risk would be when the platform and hence personnel can be said to be at an elevated risk of ship collision if attendant vessels are in close proximity to the platform and specific controls are implemented during the vessel visit in order to manage the risk. However, the predicted risk from extreme storms differs from this type of hazard as the storm cannot be controlled, therefore the only additional measure that could be implemented to mitigate personnel risk due to potential platform collapse would be precautionary de-staffing of the platform before the storm hits.

Since the probability of the maximum single wave in the storm can be predicted, then it follows that the probability of platform collapse due to any one specific storm can be calculated. In line with widely accepted industry practice it will generally be the responsibility of offshore Operators to demonstrate that given their better understanding of the risk of collapse within any given storm, that they continue to reduce risks to personnel ALARP.

Short Term Failure Probability within a Storm

The short-term probability of collapse is a function of the storm intensity, storm duration, current, wind and structural capacity. A Global Load Model (GLM) can be developed to convert combinations of the metocean parameters into base shear load. In this process, the wave height distribution is required, and this is assumed to follow a Forristall distribution (or alternative), which depends on the storm intensity. The collapse probability for various storm intensities can then be determined. An example, graphical representation is presented in Figure 5.

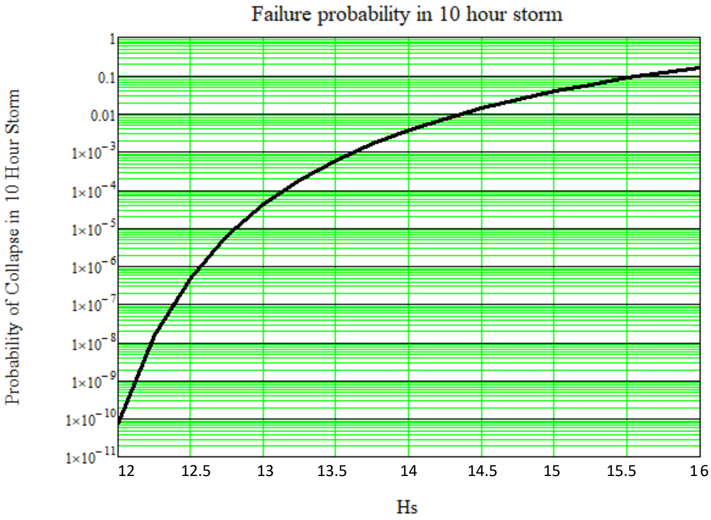

Figure 5. Example probability of failure in a given storm of duration 10 hours

Risk Acceptance Criterion for Short Term Failure Probability within a Storm

As noted, offshore Operators will need to determine what is an acceptable probability of platform collapse while people remain on board. This then can be used to define the precautionary de-staffing sea state. However, this is not necessarily an easy criterion to define because, when considering the acceptable level of risk for a single, predicted scenario, there is no current industry accepted standard other than to ensure that risks are As Low as Reasonably Practicable (ALARP). Based on discussions with a number of operators, there is typically a range of approaches i.e. from an order of magnitude less than the annual risk (e.g. 10^{-3}) to that equal to the annualised risk (e.g. 10^{-4}). It is expected that an acceptable probability of collapse during a storm while crew are on board will fall within or close to this range. There can be some resistance to accepting a 'risk in a storm' collapse probability in the region of 10^{-3} since it can be interpreted as being significantly higher than the annualised risk, but this is a false equivalence i.e. the two risk criteria cannot really be directly compared on a like for like basis. It is worth recalling that the annualised risk frequency takes into account the weather / sea state conditions for a large number of years and for all seasons (including summer where conditions are effectively calm). In comparison, the forecast storm that can result in an unacceptable level of 'risk in a storm' is unlikely to occur on a yearly basis and so needs to be taken in isolation with its own, appropriate risk acceptance criterion. This requires a change in how the workforce understand risk.

One possible way to define this criterion is via a corporate risk matrix. These company risk matrices combine frequency or probability of an event combined with the event's potential consequences. For staffed offshore platforms, the consequences of a platform collapse during an extreme storm are likely to represent the highest level of consequences on the risk matrix, particularly when considering that any rescue and recovery efforts will be prevented by the storm itself. This leaves the frequency / probability side of the matrix to be defined. The frequency can be equated to the annualised frequency currently used in QRA i.e. including all combinations of weather conditions over the long-term distribution, including calm summer months where there is effectively no risk of platform collapse. When a storm is forecast, then the risk matrix would need to adopt the probability ranges for single failures on the risk matrix rather than the frequency ranges for continuous operations. Simplistically, if an incident is 'possible' and has the highest level of potential consequences then the risk of not reducing the risk (in this case by precautionary de-staffing) becomes 'unacceptable' and would prevent continued operation.

This is not to say that the risk matrix approach is necessarily the best or only approach to defining an acceptable 'risk in a storm' de-staffing criterion. Other possible options could include the use of an FN (frequency vs number of fatalities) curve. Many offshore Operators already have tolerability limits for FN curves, and it may be possible to use the predicted number of fatalities e.g. assume 100% of POB (personnel on board) and calculate the upper limit of tolerable frequency from the FN curve. This approach is one that is commonly applied in addressing the need to define upper limits of tolerability for single events or hazard classes. This method would of course only be able to say when a risk is intolerable rather than ALARP.

There are, of course, other measures that may be implemented to reduce the likelihood of platform collapse while staffed before precautionary de-staffing is implemented. This includes enhanced structural inspection and maintenance regimes to ensure that the structural integrity of the platform is optimized. However, clearly these measures are to an extent restricted by the inherent design of the structure, essentially determined prior commencement of offshore operations. Thus, precautionary de-staffing remains an effective measure that should be considered when managing the risk to life from extreme storms. The process of precautionary de-staffing itself may incur some risks e.g. the helicopter risk of transporting personnel to shore or other offshore installation and then the return trip to the platform for remobilisation after the storm has passed. These are considered later.

Frequency of Precautionary De-staffing

It is worth considering the likely frequency of precautionary de-staffing to determine if this is likely to impose overly onerous restrictions. For a Northern North Sea facility, the 10,000yr wave height is 36.2m with the risk associated with this occurring within a storm and the return period of occurrence shown in Table 1.

The forecast uncertainty is also a key variable when considering pending storms. A range of methods are being used in industry from a distribution of uncertainty, ensemble data combined with a response based model to a simple adjustment or bias factor. The subject of forecast uncertainty is understandably complex and is worthy of examination and discussion via its own separate paper. For the purposes of this paper the adjustment factor recommended by the NORSOK (2015) standard for storm uncertainty of 1.5m for a forecast 72hrs into the future, 1.1m for 48hrs and 0.7m for 24hrs is used since these generally align well with decision making milestones for precautionary de-staffing i.e. the decision to down-staff the non-essential crew would typically take place 72 hours before a storm is due since this would generally involve several helicopter flights and actions required to shut-down and make the platform safe would often have to start at this point. The decision to remove the remaining essential crew could perhaps be delayed to 24 hours before the storm is due, may not actually occur due to a change in the forecast, and would typically involve one helicopter flight.

From the results in Table 1 (Keys, 2019) it can be seen that the Northern North Sea facility would reach the ‘in a storm’ risk limit of 10^{-3} with a forecast peak sea state of 14.9m. The annual return period of this sea state is 89 years, when considering the forecast uncertainty for 72 hours prior to the peak, which is typical for the amount of time required to start down-staffing a facility and is also usually a period when helicopter travel is still within the safe operating requirements, the return period of occurrence is 18yrs or approximately once is the life of the facility. To be clear, this does not mean that structural loss of the platform is predicted on this frequency but rather that the initial down-staffing of non-essential crew is expected on this frequency. Further, for the majority of precautionary de-staffings, the maximum wave height experienced during the storm will be less than the critical value that would result in structural loss of the platform.

Probability of 36.2 m wave in a storm	**Hs**	**Return Period of Hs based on Forecast Uncertainty**			
		72 hrs	**48 hrs**	**24 hrs**	**Peak Storm**
		1.5 m	**1.1 m**	**0.7 m**	**0 m**
Most Probable Maximum	20.1	4849	7471	11512	24534
10^{-1}	17.9	450	693	1068	2275
10^{-2}	16.2	72	110	170	362
10^{-3}	14.9	18	27	42	89
10^{-4}	13.9	6	9	14	30

Table 1. Return Period vs ‘in a storm’ risk for typical UK North Sea facility

Many of the aging facilities within the North Sea were designed to older codes, used metocean wave height estimates that have been superseded and are now predicted to be greater, as well as have a number of age related capacity reductions. Due to these conditions the annual risk of collapse is usually greater than 10^{-4}. With this higher risk, the occurrence of having to de-staff based on the criteria discussed previously also increases. From the range of facilities assessed the return period for de-staffing for some assets may be as low as 1 in 4 years. Effective integrity management programs can provide a better understanding of the capacity of these aging assets which can then increase this return period closer to those for new facilities. With a de-staffing sea state based on the acceptable risk levels identified the annual risk is also reduced significantly and brings the overall risk regardless of facility age, design or location to a similar order.

This paper only details the scenario based on the single variable of maximum wave height. Full structural reliability studies of facilities exposed to extreme conditions includes the combination of facility weights, wave heights, current and wind effects which gives a more complex failure surface, however the outcome for fixed structures is generally wave governed and therefore the de-staffing requirements are similar to the results shown here.

In conclusion, from the range of facilities studied the current approach of leaving facilities with crew on board during extreme events, 100yr events or greater, is likely to be exposing personnel to an avoidable risk that is greater than would be considered reasonable by industry. On this basis, where storms can be forecast more than 3 days in advance, it is suggested that all facilities have a de-staffing condition identified based on a set of environmental limits. These limits would be set to align with a facility operators risk acceptance level.

Risk Trade-Off

As with many risk related decisions, the decision of whether or not to implement a risk reduction measure is not a binary choice. Rather, there is a risk trade-off that must be fully understood and assessed. The most obvious trade-off related to precautionary de-staffing would involve the risk associated with transporting the crew back to shore by helicopter, particularly since this may involve helicopter flights at or approaching their specified weather limits. The helicopter risk associated with normal crew changes (in normal, operating environmental conditions) is generally well understood and included in the platform QRA although it should be recognised that these helicopter risks are based on small number of historical, fatal accidents which means that there can appear to be a spike in the risks whenever the next fatal accident occurs. Thus, it is important to only consider these risks in fairly general terms and understand that we don't really know how much, if any, increase in risk may be experienced in more testing flying conditions.

In simple terms, the use of helicopters for managing this particular hazard should not be ruled out on the general basis that helicopter flights are risky since the industry and offshore workforce already accepts this risk as a normal part of the working year. Rather, we can assess whether the risk of de-staffing by helicopter puts the workforce at a higher risk than staying on the platform during an extreme storm. Since the platform collapse risk is being discussed on a 'risk in a storm' basis, we must similarly assess the helicopter risk based on a single event basis i.e. only related to a single precautionary de-staffing.

Further, we must accept that the helicopter flights will only go ahead if the helicopter company, pilot, and offshore Operator are comfortable that they can do so safely i.e. if the individual storm characteristics are such that they prevent flying in normal operating limits then the flights will not go ahead. Thus, there should be no appreciable increase in risk from the historical accident frequency.

If we consider a typical platform with a POB (personnel on board) of around 100 people, then the potential loss of life (PLL) related to precautionary down-staffing and de-staffing to shore for a conservative flight time of 2 hours is approximately 6E-04 fatalities. The return trip would incur the same risk for a total of approximately 1.2E-03 fatalities. The other side of the risk trade-off is if precautionary de-staffing does not take place and the 'risk in a storm' collapse probability is assumed with no prospect of survivors since rescue and recovery efforts would not be possible in such a storm. This can be calculated as 1E-01 fatalities (100 POB x 1E-03 collapse probability) i.e. approximately two orders of magnitude higher than the risk incurred by helicopter transport. Now these are fairly simplistic calculations for illustrative purposes only, but they do show that the risk trade-off firmly shows a bias for carrying out the precautionary down-staffing and if required de-staffing. To do otherwise would, in effect, require a reverse ALARP argument to be made.

There may also be other risks related to the precautionary de-staffing that should be considered in the risk trade-off e.g. there may be risks associated with putting personnel back on board the platform after the storm has passed and some of the hydrocarbon systems on board have been impaired by the storm. This is a reasonable point to consider but two counter-arguments can be made: 1) if precautionary de-staffing does not take place then those personnel on board would similarly be exposed to these risks; and 2) it should be possible to put in place proper plans for safe remobilisation to the platform after a storm e.g. ensuring that adequate detection systems are in place, or placing a forward, core team on board the platform to ensure the platform is safe before it is fully re-staffed. This latter point should not be too onerous since lessons can be learned from those regions (e.g. Gulf of Mexico) where precautionary de-staffing is not an uncommon event.

Finally, given the likely catastrophic consequences of a platform collapse in an extreme storm (i.e. multiple fatalities) then, even with the associated uncertainty over modelling and forecast predictions, the precautionary principle and an aversion to risk / bias to action should be implemented in line with good practice.

Logistics

The preceding discussion is not intended to underestimate the logistical complexity that would be involved in implementing a precautionary de-staffing policy. The following list is not intended to be exhaustive but rather indicative of some of the logistical issues to be faced and overcome:

- Coordinating the helicopter response for multiple platforms if more than a few require simultaneous de-staffing. This includes a clear understanding of the decision-making timeline and milestones for de-staffing e.g. at what point does the decision need to be made to start the helicopter down-staffing and de-staffing before the incoming weather conditions will preclude the possibility of flying. This becomes more difficult when multiple platforms are involved. This may be partially solved by substitution of regular crew-change flights on other platforms for de-staffing flights. This may also be helped by early decision making on down-staffing non-essential people such that sufficient resources are available once the final decision is made to fully de-staff.
- Safely shutting down the platform. Most North Sea platforms have been designed for full staffing and are not easily put in a safe, shut-down mode without crew being on board. There are a number of logistical and process issues related to this, but these should be capable of being overcome if sufficient pre-planning is carried out.
- Shutting down one platform that has a knock-on effect on other platforms e.g. if the platforms are linked by a common pipeline system then the entire pipeline system may need to be taken offline. This is particularly true if the platform being de-staffed is the hub or reception platform.
- Putting people back on the platform and making sure it is: safe; has power; has potable water; etc.

However, while these logistical issues are not insignificant, it is important to remember that precautionary de-staffing takes place in other parts of the world and often in large numbers i.e. the respective size of a hurricane in the GoM, compared to a

North Sea extreme storm would suggest fewer platforms may need to be de-staffed in the North Sea. The lessons learned from these other regions should be readily distilled and enacted within the North Sea providing that the issues are understood, and sufficient efforts are made to solve them.

What is certain is that individual Operators can implement their own precautionary de-staffing plans, but that a cross-industry response is essential if the competing demands of different operators are not to overwhelm the logistics resources. To enable such a cross-industry response, it is likely that there would need to be: 1) commonality of risk acceptance criterion; 2) commonality of weather forecasting data and methods; 3) an acceptance that a prioritisation system may be required in some instances e.g. priority of de-staffing is given to those platforms most at risk through either pre-existing deficiencies in platform structural integrity or due to their location within the direct, predicted path of the storm.

Conclusions

For non-forecastable events such as Seismic or loss of hydrocarbon containment, the annualised risk approach historically used in QRA is appropriate but for forecastable events such as extreme storms this current approach of leaving facilities with crew onboard may be exposing personnel to a higher risk than is reasonable.

A precautionary de-staffing criterion is therefore appropriate for all facilities but is likely to only be needed at most once in the facilities life for code-designed and maintained platforms. Therefore, although cost implications for the de-staffing event are considerable over the life of the asset they should not be overly onerous.

If all platforms had a consistent de-staffing criterion, the life-safety risk should be constant regardless of the age, state and type of facility.

Precautionary de-staffing should not be referred to as emergency response since this generally refers to the measures put in place to recover from a hazard that occurred e.g. a fire or explosion. Rather this should be considered as part of normal operations with regards to normal MAH management e.g. in the same way that personnel are removed from the immediate area of a planned crane lift so as to not expose them to unnecessary risk.

Conflicts of Interest:

None.

Acknowledgements:

None.

Notes:

None.

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Joe Quinn is a Principal Safety Engineer at Atkins SNC-Lavalin in the Oil & Gas Division. Joe has over 20 years' experience in the oil and gas industry in all aspects of technical safety. He has worked on most types of offshore installations including new projects and ageing assets and in various regions including the UK North Sea, Gulf of Mexico, Australian North West Shelf and West Africa. Joe has an in-depth knowledge of risk assessments, QRA methodologies and risk acceptance criteria.

Joe has been involved in the assessment of risk related to extreme storms for over a decade.

Dr Matt Keys is the Global Technical Director for Offshore Structures at Atkins SNC-Lavalin in the Oil & Gas Division and works with over 250 integrity experts that together service a significant proportion of the worlds aging fleet of offshore platforms. Matt has over 20 years' experience in the oil and gas industry in both brownfield and greenfield structural analysis, design and Integrity management from conceptual through to detailed design, complex reassessments and overall integrity management while operating.

Including the specialist skills of non-linear FEA, structural reliability analysis and fluid structure interaction using CFD.

Matt's experience covers some of the oldest assets in the North Sea, Middle East, Australia and Gulf of Mexico to the newest floating facilities recently installed in Australian waters.