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SEMISUBMERSIBLE IN SERVICE EXPERIENCES ON THE NORWEGIAN CONTINENTAL SHELF

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ABSTRACT

Semisubmersible Mobile Offshore Units (MOUs) have been used on the Norwegian Continental Shelf since the mid 1960's and since the late 1980's also as production units. During these years a significant amount of experience data has been gathered and systemized.

This paper gives an overview of reported incidents in the period between 2000 and 2020, related to the structure and the maritime systems on semisubmersibles operating on the Norwegian Continental Shelf. Incidents, accidents and damages are reported by operators and rig owners to the PSA. These are summarised in this paper and includes cracks, dents from wave actions, anchor impact on structures, horizontal and vertical wave impacts and ship collisions. In addition, failure of the dynamic position keeping system, mooring system breakage and incidents related to stability and ballasting have been reported.

The paper provides numerical values of the occurrence of many of these incidents, where possible, in addition to an overview of the number of semisubmersibles active on the Norwegian Continental Shelf. In addition, a listing of accidents and incidents are provided and to some extent a summary of the incidents are provided for a possible further evaluation of common causes, importance and the possible consequences of these accidents, incidents and damages.

One fatality due to horizontal wave impact have been experienced in the period evaluated and a continued focus on air gap and wave in deck loading is important. However, these issues have later been better standardized by the class societies and the focus from PSA now is to ensure that the operators and rig owners are operating according to these standards. The main challenge for semisubmersibles continues to be operational issues related to stability and ballasting incidents, both because of the observed frequency and the potential consequence of such incidents.

Keywords: Semisubmersible, cracking, corrosion, wave impact, mooring, stability, ballasting, collision, dents and topsides.

ABREVIATIONS

CODAM = PSAs Corrosion and Damage Database; **DP** = Dynamic Positioning; **FPU** = Floating Production unit; **MOU** = Mobile offshore unit; **NCS =** Norwegian Continental Shelf; **NMA** = Norwegian Maritime Authority; **PSA** = Petroleum Safety Authority Norway; **RNNP** = Trends in risk level in Norwegian Petroleum activity.

1. INTRODUCTION

Semisubmersible Mobile Offshore Units (MOUs) have been used on the Norwegian Continental Shelf (NCS) for drilling and accommodation purpose since the mid 1960's. In addition, Semisubmersibles Floating Production Units (FPUs) have been used on the NCS for petroleum production since the late 1980's and have become increasingly common during the late 1990's.

On the NCS, the operators are obliged to report structural damages to the Corrosion and Damage database (CODAM). Rig owners and operators are obliged to report a selected number of key performance indicator data to the Risk level on the NCS database (RNNP). In addition, the operators and rig owners are obliged to report incidents continuously to the PSA Incident database. All these databases are manged by the Petroleum

Safety Authority Norway (PSA). During these years a significant amount of experience data has been gathered and systemized. The information used in this paper is based on these data, primarily as reported to the PSA's CODAM and RNNP databases. In addition, some information is taken from other communication with operators and rig managers.

Figure 1 gives an estimate of the annual number of semisubmersible platforms on the NCS. The mobile units includes both drilling units and flotels. For mobile units, the estimate is based on the number of days in activity on the shelf. In addition, as shown in Figure 1, 6-8 semisubmersible platforms have been used as production platforms.

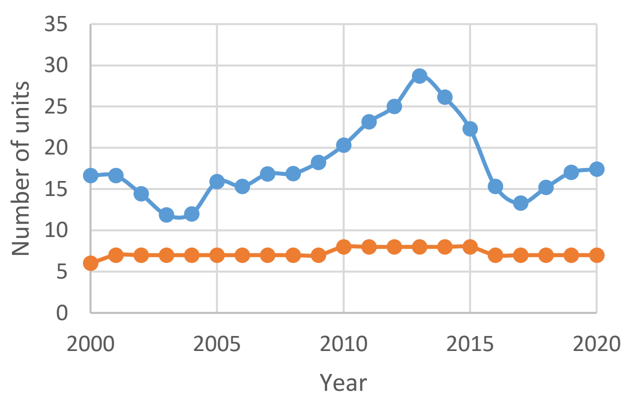

Figure 1: An estimate of the annual number of mobile semisubmersible units (blue) and semisubmersible production units (red) used on the NCS in the period 2000-2020.

2. CRACKS

Structures in semisubmersibles are exposed to fatigue cracks caused by cyclic wave loading and, in some cases, also enhanced by fabrication defects and residual stresses. Cracks occurs more frequent in semisubmersibles compared to fixed offshore structures like jackets. This is due to the vast number of local details in the hull, like scallops, slots, lugs, air-holes, cut-outs, doubling plates, penetrations and bracket-toes.

In the CODAM database, cracks are reported by the operators as major, minor and insignificant severity. Major severity will for the purpose of this paper imply cracks that may threaten the integrity of the main loadbearing structure. Such cracks include hotspot connections between:

- columns and pontoons (2),
- columns and braces (5)
- pontoons and braces (0),
- columns and deck (0),
- pontoons to pontoons (0),
- braces to braces (0),
- braces to deck (1),
- transitions in braces (5).

The number of occurrences of major cracks are indicated in parathesis.

Minor severity will for the purpose of this paper imply cracks that may have influence on the integrity of the main loadbearing structure and can develop to a crack of major severity. This includes cracks in the hotspots of support structure of important equipment and a penetrating crack in internal or external watertight boundaries. Typical examples will be hotspot connections in:

- support structure of fairlead connections,
- support structure of crane pedestals,
- support structure of flare towers,
- support structure of topside modules,
- watertight bulkheads or hull boundaries with potential of substantial flooding.

Insignificant severity will for the purpose of this paper have the remaining cracks that are not classified as major or minor.

Due to the nature of the PSA reporting system, several cracks in the same year may have been reported as a single crack. A total of 13 major and a total of 30 minor cracks incidents are reported for the semies between 2000 and 2020. In addition, a high number of cracks rated as insignificant are reported in the CODAM and RNNP system in the same time period. However, these insignificant cracks will not be subject for further discussion in this paper.

The annual numbers of cracks classified as major and minor on all types of semisubmersibles on the NCS in the period 2000-2020 are shown in Figure 2.

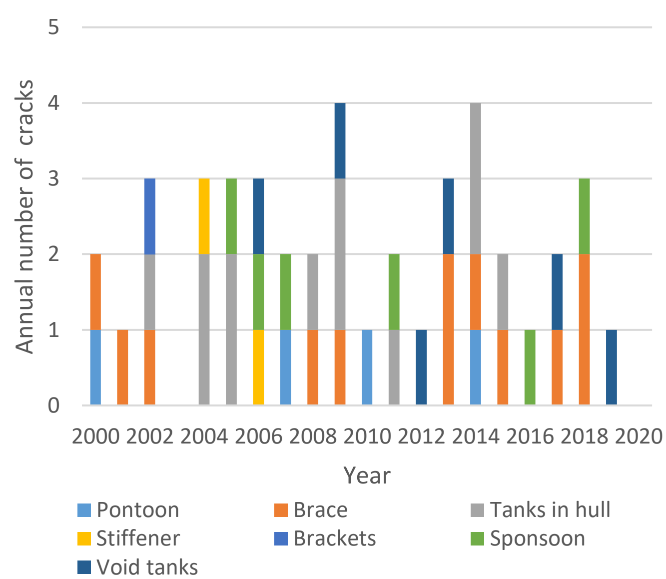

Figure 2: Production semi-submersibles and mobile offshore units: The annual numbers of cracks classified as major and minor on semis on the NCS in the period 2000-2020

As can be seen from Figure 2, a total of 43 major and minor cracks are reported (through thickness cracks towards the sea or severe cracks inside the hull or braces). There is no specific trend in the data from this period, but the average number of reported cracks per year is close to two. Local fatigue sensitive details are found in all parts of the hull. However, the majority of the experienced cracks are localized in the columns.

For the mobile offshore units, the annual numbers of cracks classified as major and minor in the period 2000-2020 is shown in Figure 3. When comparing Figures 2 and 3, it can be seen that production units contribute with half the number of cracks reported. Interestingly, only two production semis have reported cracks during the relevant period and are hence contributing significantly to the statistics. One of these have been out of service since 2016 (for refurbishment), while the other is planned to be demobilised in 2022. It can also be seen that the number of cracks in mobile offshore units, seems to flatten out.

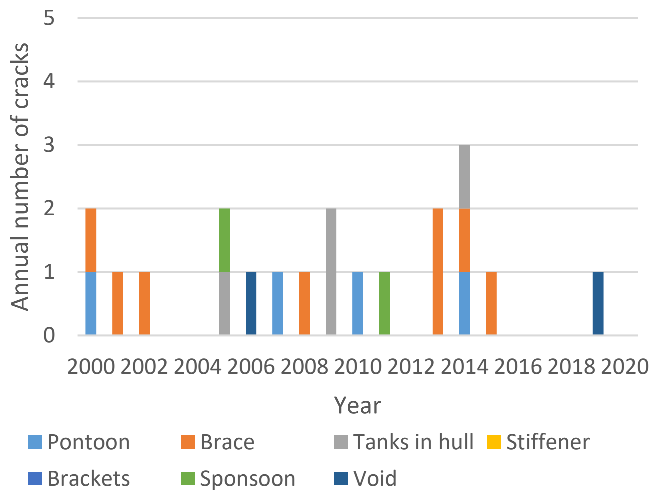

Figure 3: Mobile offshore units: The annual numbers of cracks classified as major and minor on semis on the NCS in the period 2000-2020.

Figure 4 shows the occurrence of major cracks only, with indication of the cracks found on production units. As can be seen, the occurrence of major cracks on mobile and production units is not particularly frequent and is rather equally distributed in the time period from 2000 to 2020. The majority of major cracks (70%) have been reported for mobile offshore units. However, taking into account the number of MOUs versus FPUs, the occurrence frequency is slightly higher on FPUs.

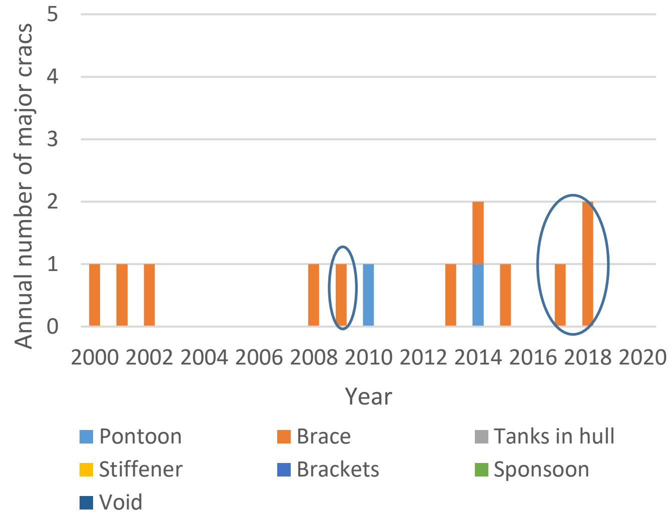

Figure 4: Major cracks on production and mobile offshore units: The annual numbers of cracks classified as major in the period 2000-2020. The occurrences on production units are marked.

From the reported incidents we can see that the majority of the major cracks are located in or around horizontal braces, as expected, while very few cracks have been reported in other areas classified as major. Some annual peaks can be identified in the Figures 2-4, which may be caused by scheduled classification intervals, inspection campaigns or winter seasons with particularly harsh weather.

Essentially, cracks can be caused by numerous different degradation mechanisms, including fatigue, overload, hydrogen embrittlement, temperature and fabrication defects. However, most of the cracks reported are said to be caused by fatigue failure, while the crack in braces to deck, mentioned above, is reported to have its root course in large fabrication defects.

Looking more into the details of the units when the major cracks were discovered, the following can be seen:

- major cracks are reported for 8 different units, whereof only one is still operating on the NCS
- seven of the units reported with major cracks were mobile units.
- the age of these varied between 14 to 36 years, with a mean value of 26 years

Based on the above, it seems like cracks classified as major is related to the age of the units. As fatigue damage is an accumulative process this is as expected. However, in the recent years many of the older semisubmersibles have left the NCS and this will probably have influence on the reported number of cracks in years to come. As a result, it is difficult to generate scientific rigorous trends for the fatigue cracking as a function of age, and to indicate a limit for safe operations. However, an operator of an older semisubmersible needs to be aware that the likelihood of fatigue cracking will increase with age, and the structural integrity management should be adjusted to this likely trend.

3. VERTICAL WAVE IMPACTS

A total of 29 wave impact incidents, distributed on 17 platforms, were reported in the period 2000-2020. A total of 27 of these were vertical wave impacts and the remaining two were horizontal wave impacts. Occurrences of wave impact have been recorded typically in sea states with high steepness. Most of the remaining incidents resulted primarily in local damage but represented a potential for harm to personnel (Kvitrud and Løland 2018).

Denting of the hull of a semisubmersible is normally regarded as the most significant result of vertical wave impact. A total of 6 such dents and corresponding structural damages due to direct wave action or wave run-up have been reported in the period from 2000 to 2020. The following paragraphs are describing these 6 incidents.

During a storm in November 2008 with a recorded mean wind of 21 m/s and a sea state of Hs = 9.2 meter, a mobile offshore unit was waiting for better weather conditions to be able to start operation by pulling anchors. The rig was de-ballasted 2 meters and was disconnected from the well. After the weather peak passed, the rig was hit by a wave on port forward column. This wave caused a wave run-up hitting the double bottom under the living quarter on the port forward side of the rig, causing deformations of the structure on lower cabin decks and in the double bottom structure.

In January 2016, the storm “Tor” caused several incidents due to wave impact. At the location of the first of these, the storm with a recorded mean wind speeds up to 70 knots (38 m/s) and a corresponding sea state Hs = 10m. The storm caused a wave impact or run-up at the aft starboard column, indenting the double bottom plating under the engine room. The area indented was estimated to be 2.5 by 7 meters. A pump-motor foundation in the corresponding area was also found to be damaged. In addition, three stiffeners were found fractured and two girders were found dented.

In the same storm, at the location of a floating production unit (FPU), the storm was recorded to have a mean wind speeds up to 60 knots (32m/s) and a corresponding sea state of Hs=13.2 meter. The FPU was as a result hit by a wave below the deck on south-west part of the platform, most likely caused by run-up along the column. The incident caused deformations in the double bottom plating, and corresponding deck stiffeners and pipe supports. The damages were located in an area located approximately 3 meters from the column.

Furter, during the same storm in January 2016, a wave impact and run-up at the aft port column of another MOU, and damaged parts of the structure under the helideck and dented a side panel of the living quarter. The records for the location of this MOU indicates a mean wind speed to 85 knots (46 m/s) and gust up to 114 knots and a corresponding sea state of Hs = 12.3 m. The unit was de-ballasted to survival draft when two waves hit the column, one at 18:30 and the other at 19:15. The first observation of the wave impact was due to water ingress into watertight doors at port side and a notable amount of seawater on main deck. The mentioned structural damages were discovered at a later stage.

Finally, in the same storm, another FPU experienced wave impact or run-up. The sea state at this location was reported to be Hs=12.2 meter. The damage was located in way of the bottom structure of the living quarter and detected in the summer of 2016. The damaged area was approximately 5 meters away from one of the columns, on the underside of the deck box. The damaged area (aluminium stiffeners) required repair. The incident highlighted the need for new air-gap analyses.

During a storm in January 2020, a MOU was waiting for weather in operation condition. The storm was recorded with a sea state of Hs = 8 meter and wind speed of 50 – 55 knots. The windspeed dropped suddenly from 50 knots to 30 knots, within 150 seconds, causing the MOU to trim forward and list to port. Minutes later, before list and trim was corrected, the port forward column of the rig was hit by a wave coming from the forward port side. This caused a vertical wave impact on the double bottom (and ultimately a wave run-up) and a corresponding damage to the double bottom. In addition, the wave impact caused an unplanned launch of a lifeboat. The structural damages were identified in way of the port column inner side in an area of approximately 3 by 3 meters.

As indicated, most of these dents occurred during the storm Tor on January 29th in 2016. In total, two production platforms and two mobile units were damaged in the same storm. The strength of the storm Tor corresponded to a return period of approximately 5 years, with maximum recorded significant wave height of 15 meters at the Snorre field. According to Nygaard (2017), the wind speed was most likely above hurricane force, but possibly less at the Snorre field (10-minute mean wind speed 10 m above mean sea level above 32.7 m/s).

None of the reported major dents have been reported in the column area. Further, none of the indents to the underside of the deck structure seems to have a severity that can threaten the global integrity of the units. However, all incidents reported seems to originate from wave impact with a corresponding wave run-up. It seems that previous regulation and guidance did not address the subject of impact loads caused by wave run-up in a very good manner. However, some Classification Societies have later included requirements regarding minimum load effects to be applied due to wave run-up, e.g. see DNV (2021).

In addition to the above-mentioned incidents, several incidents (~21) of missing gratings, damages to handrails, stairs, light structures, stiffened plates, production equipment, drilling equipment and damages to life saving equipment have been reported in the same period. An example of the potential consequence from such wave damage to secondary and tertiary structural elements is that in 2015 a man fell 13.5m to sea due to loss of grating. However, these incidents are not further discussed in this paper.

4. HORIZONTAL WAVE IMPACTS IN DECKS

As mentioned in the previous section, 2 horizontal wave impact incidents have been recorded in the period 2000-2020. One of these horizontal wave impact incidents caused one fatality, four injured personnel and severe structural damage. The fatal accident occurred in 2015. The second, less serious accident, occurred in 2001. The incidents are in detail described in (Kvitrud and Løland 2018).

Following the fatal accident, classification societies and authorities evaluated the governing regulations at that time and it was found that improvements were needed. The improvement work resulted in new guidelines being developed, based on existing wave model tests, advanced hydrodynamic calculations, experience transfer for units in operation and search in data bases for similar incidents. Preliminary guidelines were issued as early as in 2016, and within three and a half years after the accident, the major classification societies produced revised rules and Technical Guidance on the prediction of air gap and loads from horizontal wave impact (DNVGL 2019 a and b).

One of the most important outcomes of this work are that both the operating condition and the survival condition shall be examined with regards to airgap. For the operating condition, the intention is that the rig shall always maintain a positive airgap when at operational draught. This imply that when the forecasted or the prevailing sea state exceeds the limiting sea state for positive airgap, the rig shall be de-ballasted to survival draught. Preparation and execution of the de-ballasting shall be performed in due time to ensure that the rig is at survival draught prior to the sea state exceeding the limit sea state curve.

5. ANCHORS IMPACT DAMAGE

Two occurrences of anchor impact damage to hull and bolster have been recorded in the period 2000 to 2020. One of these was regarded as significant.

In November 2012, the impact from a loose anchor resulted in eight punctures in the port pontoon, causing flooding of two ballast tanks and a corresponding list of approximately 5.8 degrees (Andersen et al 2013). The incident occurred in a sea state with a significant wave height of 10.9m. The direct cause of seven of the punctures were impacts from the loose anchor. The last puncture occurred when a damaged part of the anchor bolster failed due to fatigue. This damages to the bolster had developed over time and after the failure of the bolster the remaining parts of it did not prevent the anchor from hitting the hull directly. Then, the anchor was hanging freely and was able to hit the hull repeatedly and damaging the pontoon. Damages in different stages of development was observed on all four bolsters. The incident was mainly caused by inappropriate choices made in the design, such as:

- the anchors could not be securely attached to bolster,
- the bolster was not designed for the actual loads from the anchors,
- doubling plates used as weak links failed due to fatigue.

As a result of the incident, a total of 336 persons were evacuated by helicopters. The remaining 38 crew members remained on the platform for the transport to shore for repairs (Andersen et al 2013 and 2014).

In the second incident, the manoeuvring of an anchor in high seas led to the movements of the anchor, which further led to the puncture and a subsequent minor leak into a tank. The leakage amounted to 10-20m^3 of water per hour. In addition, the anchor impact led to three dents in the fairlead supports.

In addition, one incident where a fluke anchor damaged the bolster and parts of it fell apart, without the anchor hitting damaging the hull, is recorded.

6. SUPPLY VESSELS COLLISIONS

In the time period between 2000 and 2020, eleven collisions have been reported between visiting vessels and semisubmersible units. The two most onerous events occurred in 2004 and 2010. These two incidents are briefly described in this section.

In 2004, the supply vessel hit a MOU while on autopilot. The supply vessel was rather new (3 months in service) and the crew had insufficient training and understanding of the vessel's manoeuvring systems. The collision occurred at 3.7 m/s speed. The mass of the supply vessel was about 5000 tons, and the collision energy was estimated to be 39 MJ (Munch-Søegaard and Pettersen 2004). The damage to the MOU amounted to two punctures in the upper part of the column. The supply vessel experienced damage to the upper part of the bow structure. After the incident, both the supply vessel and the MOU sailed to shore for required repairs.

In 2010, a supply vessel was working close to a MOU platform on the leeward side. During manoeuvring, the propeller of the supply vessel got stuck in a wire in the anchoring system of the MOU. The supply vessel then lost control of the manoeuvring and repeatedly hit the MOU platform for two hours, before it was towed away. The MOU suffered damage in two columns, including one puncture. The vessel had six punctures in the cargo and ballast tanks and water ingress into the engine room. The dead weight of the supply vessel was 3.325 dwt, but the collision energy of each impact was low. However, the number of impacts may have amounted to several hundred (Marathon Oil, 2010).

7. DYNAMIC POSITIONING SYSTEMS

A total of 16 loss of position incidents are reported for semisubmersibles from 2014 to 2020. Four of them were on flotels and 12 on mobile drilling units. The incidents have had a mixture of severity and pollution, damage to drilling and production equipment, falling objects and automatic lifting of gangway with personnel were the most serious incidents. In total, about 300m^3 is oil-based and 70m^3 of water-based mud went into the sea at the events.

Figure 5 illustrates the number of incidents based on the assumed cause of the incident. Software and hardware computer errors are referred to as "Software", lack of thruster capacity is classified as "Thruster", wrong understanding of position is labelled "Position", and operational or procedure failures are referred to as "Operation".

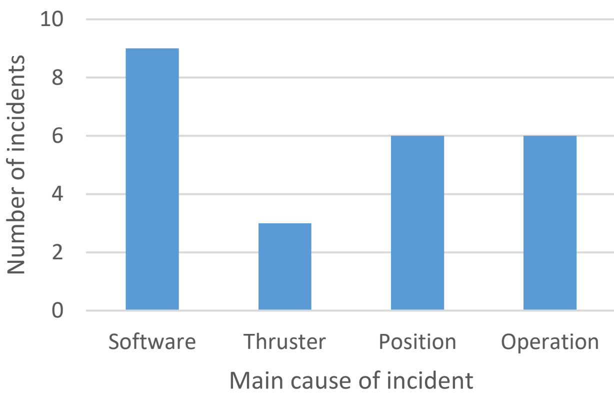

Figure 5: The number of incidents relating to the dynamic positioning system in 2014-2020 and main causes. Several incidents have more than one main cause.

The investigations of the incidents are performed by the operators of the units. Many of the cases are explained as "software problems" in the investigation reports. The frequency of incidents decay as a function of the age of the units. Also, the most critical cases occur for the newest units. This kind of behaviour is usually explained as deficiencies in design, fabrication, and commissioning, together with unsatisfactory quality control or verifications. Since known errors usually are corrected, the number of faults is reduced over time, and consequently the number of incidents. Important contributors to errors on new vessels are also new and unexperienced crew, new complex facilities, lack of vessel specific training and knowledge of the unit and how it behaves under various conditions (Kvitrud 2019).

8. MOORING SYSTEMS

Mooring line breakage failure is one of the most common incidents on a semisubmersible. In the period 2000-2020, one triple line failure, one double line failure and 28 single line failures during operations have been reported. However, none of these have resulted in a total mooring system collapse. In a previous paper (Kvitrud 2014) the common causes of these line breakage failures have been discussed.

A MOU experienced the triple line failure in June 2000. In significant wave heights of about 8.5 meters the facility drifted 310 meters. The anchor lines crossed several export pipelines as well as interconnection lines. Two of the lines failed at the same time and the third about 15 minutes later. The cause of the failures was a combination of fatigue cracking and wear and tear degradation of a CR link (Detachable Chain Connecting Link).

In 2012 one of the mooring lines on a MOU paid out, which resulted in a loss of position. The situation was stabilized but the mooring line paid out a second time and the rig lost its position once again. This led to the failure of the anchor wire of the neighbouring mooring line. The thrusters were taken into manual control to avoid further fractures of the remaining mooring lines. Heavy seas and strong wind and current then forced the rig out of position by 8.7 meters, resulting in the failure of the anchor wire of the mooring line that paid out first.

Examples of reported single line failures:

- A mooring line failed in heavy seas and strong wind in December 2002. One of the anchors dragged which led to the loss of the anchor on a second mooring line.
- A fibre line was cut by a trawler fishing in the area near by the semisubmersible in February 2006.
- A chain failed due to fatigue on a MOU in October 2006. This resulted in the paying out of a second mooring line and the rig dropped out of position.
- In October 2011 a three-year-old kenter joining link failed due to fatigue and corrosion.
- An anchor chain failed on a MOU in January 2012. Bad weather on the location led to overload in a mooring line.
- A chain failed in still water on a MOU in 2012. It was later reviled that the chains had been fabricated under wrong conditions.
- In July a chain failed on a MOU. The chain had severe corrosion. An investigation of the failure stated that the failure occurred due to either brittle fracture or fatigue crack growth.

In addition to the mooring line failures discussed above, there are several line failures resulting from dragging of anchors, anchor lines paying out, brake and winch failures. Mooring lines also fail during the installation phase, but these are not included as they are not a safety issue for the unit during operation.

9. STABILITY AND BALLASTING

In the aftermath of the well-known Alexander L. Kielland accident in 1980, the Norwegian Maritime Authority (NMA) updated their regulations related to stability and ballasting operations. These regulations include strict requirements regarding stability in damaged conditions and reserve buoyancy. The NMA regulations (1991 and 2016) are the prevailing regulations for all floaters on the Norwegian Continental Shelf (NCS).

A total of 21 semisubmersible stability and ballasting incidents have been reported in the period from 2000 to 2020. These incidents include various types of reduced stability, incorrect ballast operations, faults in the seawater system and leakages (leakage volumes greater than 40 m^3 is included). Of these, 16 cases are regarded to be of minor severity, while 5 cases are regarded to be of major severity (i.e. an incident with a high potential). Of these major cases, 4 incidents involve mobile offshore units, and 1 incident involves a permanently placed semisubmersible production platform.

Incidents related to stability and seawater system (including the ballast system) of major severity are rare but do occur. A total of 21 stability related incidents are reported and can be grouped into the following causes:

- operational failure or lack of knowledge,
- electrical short circuits,
- technical failure of equipment such as valve failure and pipe failure,
- impact damage and puncturing, e.g. from anchor impact or ship impact
- structural damages such as corrosion and cracks,
- design errors.

In the following, a brief description of the 5 cases of major severity is given.

In 2010, a floating production unit (FPU) experienced an incident before it was due to be towed to the offshore location. Due to a fault causing short circuiting in the ballast control system in the safety automation system (the SAS I/O cabinet) at the top of a column, the facility listed three degrees. This fault caused all the valves between ballast tanks in one of the quadrants to open, which in turn led to a shift in the ballast water and thereby also in the unit's centre of gravity. Valves in the ballast water intake from the sea remained shut. The fault in the electrical supply spread to other equipment. Input boards malfunctioned and required manual resetting after the loss of power. The software controlling the input boards had wrong parameters. The software opened all the valves because of the fault in the input boards. The interlock designed to prevent multiple valves from opening simultaneously failed too, after the valves had already been opened incorrectly. The applicable ballasting procedure did not include the use of an emergency stop during a crisis (Aker Solutions 2010 and PSA 2010).

In 2012, a mobile offshore unit (MOU) suffered a seven-degree list (Eni 2012 and Dybvig et al 2012). Around 14:40, the control room operator noticed a movement in the unit indicating that the rig was trimming in the aft direction. The control room operator started to operate the ballast control system to counter the effect. A sea chest valve and a ballast valve were opened. These actions had no effect, and the trim continued to develop. The control room operator tried several other measures but with no effect. The control room operator then lost the overview of the situation and became more and more stressed. The stability section leader and the offshore installation manager arrived shortly thereafter and started to work with the difficult situation and the ballast control system together. The "close all valves" function (the emergency stop) in the ballast control system was activated. By that time, the rig had an aft trim of seven degrees. The situation was then stabilised. Eni's conclusion was that the control room operator in question was not fully qualified to be alone in the control room. In the aftermath, it was concluded that two valves had been opened from the sea to an aft ballast tank with a volume of 1186 m3 in a pontoon. If this tank had been fully topped up, the unit could have developed a trim of 12.3 degrees (Eni 2012).

As previously described, in November 2012 a loose anchor resulted in eight punctures in the port pontoon which caused flooding of two ballast tanks and a corresponding list of approximately 5.8 degrees (Andersen et al, 2013).

In 2017 the port forward pump room of the pontoon on a MOU was flooded due to a rupture in a compensator bellow on the discharge side of fire water pump no. 4. The rupture generated free flow of water into the pumproom. With malfunction of the ballast pumps (short circuit) on port side the crew was not able to use these to drain the pump room. A small amount of water was also observed in the tunnel and thruster room adjacent to the pump room, leaking through the ventilation pipes. The watertight integrity was therefore established by closing the watertight valves in the ventilation system. Due to the malfunction of the port side ballast system, the platform listed approximately 5 degrees at the start-up of counter ballasting in the opposite direction. This operation increased the draught from 23.15 meters to 25.6 meters. The total water ingress to the pump room was reported to be approximately 600-1000 m^3.

In October 2020, a MOU was performing tests of the dynamic positioning system (Dynamic Positioning Failure Mode and Effect Analysis). The drilling rig was during testing located outside the 500-meter zone and not connected to the well. During this test, starboard and port ballast HPU were isolated from each other. During the reset of the system, isolation valves were operated in the wrong order which led to ballast valves on the port side to open, causing the rig to list 6.1 degrees before the ballast valves were closed. The rig returned to normal ballast condition and even keel shortly thereafter.

All the five incidents described above were regarded as major severity, as 4 of these cases included severe loss of control with the ballast system and 1 case included severe damage to hull and subsequent water ingress. All cases resulted in severe listing. However, none of the incidents resulted in a trim or list larger than 17 degrees, regarded as the maximum allowable angle of inclination according to governing regulation (NMA 1991). As a result, the reserve buoyancy of these units was not actually tested, and as a result the margins for a total loss of the units were robust.

10. SUMMARY AND CONCLUSION

The paper provides an overview of the most significant incidents and accidents in the period 2000 to 2020 involving semisubmersible units. The only fatal accident in this period is due to a horizontal wave impact. However, new standards on airgap and horizontal wave impact loading have led to strengthening, mitigations and operational restrictions on the existing semisubmersibles which reduce this effect of this type of hazard.

Stability and ballasting remain a concern for semisubmersible units. Several incidents of water ingress have been reported and in general, operational errors are a significant contributor to such incidents. As a result, an increased attention on competency on stability and ballasting is vital.

In addition, many cracks have been reported between 2000 and 2020. Most of these have been reported as minor or insignificant cracks, but a few have been classified as major. The tendency of reported cracking is that a reduction in frequency is seen, probably as a result of that older semisubmersibles have left the Norwegian Continental Shelf.

A total of 27 vertical wave impact has been recorded in the period from 2000 to 2020. The majority of these incidents have resulted in damage to secondary and tertiary structures, like grating, stairs and handrails. These are not of vital importance for the integrity of the unit itself but poses a hazard to personnel and should not be disregarded.

The number and severity of incidents related to collision between supply vessels and the unit, loss of DP system and mooring line failures indicate that attention to these topics should continue. Operational procedures for supply vessels approaching the units and maritime ship monitoring systems have greatly contributed to a reduction in incidents. In addition, competent personnel onboard the supply vessel and with the operator is an important contributor to safe vessel handling.

Many units in operation are now using dynamic positioning as their station keeping system, a certain decrease in mooring line failures have been recorded. However, this reduction in frequency may be misleading for the units where mooring lines are being used. As shown in this paper, many mooring line failures have been reported, but the requirements for redundancy (two-line failure) have reduced the consequences to an acceptable level.

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