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The Ocean Ranger Disaster

John Price
Memorial University of Newfoundland
St. John's, Newfoundland, Canada
jdprice@mun.ca

ABSTRACT

The OCEAN RANGER was the world's largest mobile offshore drilling unit (MODU) when it capsized and sank off the coast of Newfoundland in February 15, 1982. 84 lives were lost that day. This loss was not a catastrophic failure; but a combination of several small, preventable factors. Post-accident studies, investigations and commissions have made several recommendations for improvements to safety in the Newfoundland and global offshore industries; some have been implemented and some have not.

This case study explores how the OCEAN RANGER was lost, the lessons learned, recommendations made since the disaster, and the overall impact on the offshore oil and gas industry.

1 INTRODUCTION

The OCEAN RANGER was a mobile offshore drilling unit that capsized and sank off the coast of Newfoundland during a fierce North Atlantic storm on February 15, 1982. All 84 men aboard perished in this disaster. To this day, it remains the biggest accident in the Canada's offshore petroleum industry.

2 VESSEL DESCRIPTION

MODU OCEAN RANGER was an offshore drilling unit of the semi-submersible type. She was owned by New Orleans based Ocean Drilling and Exploration Company, Inc. (ODECO). The rig was built in 1976 by Mitsubishi Heavy Industries in Hiroshima, Japan. She was classed for 'unrestricted ocean operations' by the American Bureau of Shipping (ABS) [1]. The Ocean Ranger was designed to withstand 100 knot winds with 34 m waves and a 3 knot surface current. The design allowed for a maximum drill depth of 7 600 m, in water depths up 460 m.

The general particulars of this offshore unit are presented in Table 1 below, while Figure 1 provides a photo of the OCEAN RANGER.

Table 1 - OCEAN RANGER General Particulars [1]

Length	121.9 m
Beam	79.9 MT
Height	102.7 m
Drilling Draft	24.4 m
Transit Draft	9.1 m
Drilling Displacement	38 857 MT
Transit Displacement	24 552 MT
Propulsive Power	10.6 MW
Crew	84 men

Figure 1 - MODU OCEAN RANGER [2]

The OCEAN RANGER was built to a conventional semi-submersible design. Port and starboard pontoons provided the floatation. The pontoons were connected to the topsides with eight vertical columns. The four corner columns were larger in diameter than the four intermediate columns to provide stability. The corner columns also housed three chain lockers; one for each anchor chain. It is important to note that the chain lockers were not sealed with a watertight hatch, nor was there a pumping system to empty any water that entered the lockers [3]. The columns were interconnected with transverse trusses to provide structural rigidity.

The topsides consisted of two levels. The upper deck contained the drill floor, drilling derrick, drilling supply storage, booms, anchor machinery, helideck, office space, working areas and lifeboats. The crew's living quarters were split between the upper and lower decks. The lower deck contained the generator room, machine shop and several storage areas.

The ballast control room was located in the aft most intermediate column on the port side, halfway between the drilling waterline and the lower deck. It was fitted with four portholes to enable the operator to visually confirm the drafts at each corner column. All portholes were fitted with interior, weathertight deadlights, which could be closed in the event the glass in the porthole failed. The ballast control panel was located in the forward section of the room. It had displays for both the port and starboard pontoons and the various tanks within. Pushbuttons were installed to open the valves, while separate pushbuttons functioned to close the valves. When the "open" button was pushed, the valve would open and remain so until the corresponding "close" button was pushed. The system was designed such that in the event of a power failure, all valves would automatically close [1]. As a failsafe, threaded brass actuator rods could be manually inserted into the solenoids to depress the actuator. However, these were poorly designed and it was difficult to tell if and when the actuator was actually depressed. All valves could be manually operated with a wrench in their respective pump rooms.

Each pontoon contained twelve ballast tanks, two fuel tanks and two drill water tanks. All pumps were located in the pump room in the stern of each pontoon. It is important to note the positioning of the pump rooms in the pontoons. At a trim exceeding 6 degrees, the vertical height between the pumps in the stern and the forward ballast tanks exceeded the net positive suction head (NPSH) of the pumps [1]. This was a known fact, so the ballast control operators typically deballasted the tanks in a sequence such that the forward most tanks would be pumped once a suitable trim was attained. The operators also determined that by opening the sea inlet valve, they could prime the pumps to improve the pumping rates when they were operating near the limits of the NPSH.

The OCEAN RANGER was outfitted with all lifesaving equipment required by the pertinent regulations. Although no anti-exposure/immersion suits were onboard, there were 127 life preservers, 25 life vests and 15 life rings. 10 twenty-man inflatable life rafts were fitted to the platform. The main lifesaving evacuation equipment consisted of 2 fifty-man rigid, enclosed lifeboats of the Norwegian 'Harding' Design. These were davit launched and the release mechanism was such that it could only be released in an unloaded condition; i.e. the lifeboat must be fully floating in the sea before it could be released. Lifeboat 1 was located on the port bow, while lifeboat 2 was located on the port stern, both on the upper deck. However, United States Coast Guard (USCG) regulations stipulated that lifeboats release mechanisms must have to ability to be released under full load [3]. As a result, the OCEAN RANGER carried two additional lifeboats of the American 'Watercraft' design, also having a capacity of 50 men. Lifeboat 3 was yet to be installed and was lashed to the deck in an unusable condition. Lifeboat 4 was installed next to lifeboat 2 on the starboard stern. Both lifeboat designs were self-righting in the event of capsize.

At least two more drill rigs were constructed to slightly modified OCEAN RANGER designs. The DYVI DELTA was built in 1981, while the OCEAN ODYSSEY was built in 1982. Both of these mobile offshore drilling units have successfully operated for almost 30 years, indicating that there are no major design flaws with the OCEAN RANGER design.

3 OPERATIONS

In 1982, the OCEAN RANGER was stationed 166 nautical miles (nm) southeast of St. John's, Newfoundland on the Grand Banks. She was involved with drilling wells for the Hibernia oil field. At the time of the disaster, she was drilling her third well, called Hibernia J-34, in 80 m of water [3]. Prior to her Newfoundland deployment, the OCEAN RANGER had successfully drilled wells off the coast of Alaska, in the Bering Sea, off the Eastern seaboard of the United States and off the coast of Ireland with no incidents.

For Newfoundland operations, the OCEAN RANGER was leased to Mobil Oil of Canada, Ltd. (MOCAN), of Calgary. Under this agreement, ODECO was responsible for manning and operating the rig, and MOCAN was responsible for those drilling and completion activities. 46 of the 84 men onboard were employed by ODECO, while the remainder were MOCAN personnel or contractors.

The person in charge of the rig during regular operations was the “toolpusher”, an ODECO representative. He was in charge of all drilling operations. However, while underway or navigating, a licensed mariner with the title ‘master’ assumed command, per marine regulations and the rig’s operating manual.

During the disaster the toolpusher on board held no formal academic training, but had worked his way up through the ranks, holding a variety of drilling related positions until assuming his current role. The master on the other hand graduated from the University of Maryland and held the required licenses from the USCG [1]. He had fifteen years experience serving on sea-going vessels, before working as master aboard MODUs for ODECO for ten years.

Although hydrostatic stability was ultimately the responsibility of the master, the ballast control room operator was most actively involved in managing stability through the ballast system. He was responsible to maintain a level platform at the drilling draft, as required drilling operations. To manage the stability on such a structure, it is imperative to track all variable weights, including fuel, drill, water, drill pipe, etc. As these consumables are moved/consumed, it is necessary to redistribute ballast to maintain the desired trim and draft. While this is a technical job, it was common practice for ODECO to employ individuals for this position that were not formally educated in stability. Typically, roustabouts with an interest in the job would spend some of their spare time observing the ballast control operator. When a future opening was identified, management would select such a person and assign them as an assistant to the operator for part of their regular work shift [3]. After a period of evaluation, if the roustabout was selected for the job, he would be given a comprehensive 84-hour on the job training session. He would then be a junior ballast control operator, working the alternate shift of the more experienced operator. At the time of capsize, the senior ballast control operator aboard the OCEAN RANGER had two years experience as an operator with ODECO, following the above noted scheme. The junior ballast control operator at the time also followed this scheme, but he had just recently been promoted from roustabout in January 1982, and was therefore inexperienced.

4 PRE-DISASTER LISTING EVENT

On February 6, 1982, the OCEAN RANGER uncharacteristically listed to 6 degrees while she was getting her drill water supply replenished [3]. The master had temporarily relieved the ballast control operator, who went to close the manually operated fuel valves, as refuelling was just completed. On his way to the port room, he was delayed by a watertight door that he could not open, so he called the electrician to come troubleshoot if for him. Once the operator was in the pump room, he detected the list. At this time, he rushed back to his post in the control room, where he found the off-duty ballast control operator and the master attempting to operate the ballast control system. During this time, a general call was put over the loudspeaker for all hands to don their lifejackets and report to the lifeboat stations. However, the list was subsequently corrected and the alert was deactivated.

It was reported that as the list developed, the master began to open valves to begin pumping ballast to rectify the situation. However, he failed to notice that the two inlet valves located in the sea chests were open. Under normal operations, these valves should have been closed. It was never determined who left them open, or for what reason.

After this incident, the master and the ballast control operator were reprimanded by the toolpusher. The toolpusher told the master that he shouldn't touch the controls without the assistance of an operator if he didn't know what he was doing. The master acknowledged this point and agreed to do not operate the ballast control system in the future, despite being the stability authority.

5 WEATHER CONDITIONS

During the days of February 14 – 16, 1982, a typical winter storm passed over the Grand Banks. Wind speeds of 70 knots were experienced, with gusts up to 90 [1]. Wave height was predicted to be about 9 m, with occasional waves reaching 15 m. Sea temperature was noted as -1.7 degrees Celsius. The sea was classified as 'Sea State 8'.

The weather conditions at the time of the accident were well within the design criteria of the OCEAN RANGER. The rig had previously survived similar storms. Other nearby MODUs, the SEDCO 706 and the ZAPATA UGLAND, both survived the storm [4].

6 DESCRIPTION OF EVENTS PRECEDING CAPSIZE

The following is the accepted chain of events as presented in [1] and [3].

As the storm approached the Hibernia field, the OCEAN RANGER commenced operations to disconnect the riser to ride out the storm. At 1642, it was reported that this hang-off was progressing but was complicated by the fact that hydraulic hoses for the heave compensator had got tangled up with the derrick. This problem was eventually rectified and the drill pipe had to be sheared off quickly due to the worsening storm.

Around 1900, the OCEAN RANGER reported a broken porthole in the port side of the ballast control room. The window was smashed by a wave. Located at 8.5 m above mean sea level at the drilling draft, the porthole was vulnerable to wave actions in these sea conditions. The deadlight was not secured in the closed position until after the porthole was broken. Post accident ROV inspection showed that the second porthole on the port side was also smashed.

It is not known for sure, but it is expected that this prevented the crew from pumping ballast to reduce draft after disconnecting was complete. The OCEAN RANGER reported this porthole failure to the St. John's office and the other rigs in the area, but as late as 2200 the ballast control panel aboard the OCEAN RANGER was still functioning normally.

For the next several hours, all appeared normal aboard the OCEAN RANGER. At 2250, a routine check in was made by the radio operators to the MOCAN operator ashore. At 2300, a scheduled position report was requested from the standby vessel, while at 23:30 the weather man transmitted his regular weather report.

At 0052, on February 15, the OCEAN RANGER sent out her first Mayday signal. She reported a sudden severe list of 8-10 degrees by the bow. Attempts to identify and correct the problem were unsuccessful.

Around 0100, MODU OCEAN RANGER requested her standby vessel M/V SEAFORTH HIGHLANDER to move in closer. At the same time, aerial evacuation by helicopter was requested from the St. John's office.

The last transmission from the OCEAN RANGER stated that all hands were headed to the lifeboat stations and that they were abandoning the platform. This was about 0130.

The rig sank at 0310, at which time it disappeared from radar, as seen from the M/V NORDERTOR, the standby vessel of the ZAPATA UGLAND, which was tasked to assist.

7 DISCUSSION OF CRITICAL CHAIN OF EVENTS

As all personnel aboard the offshore drilling unit were lost, event recollection is based on radio transmissions between the OCEAN RANGER, SEDCO 706, ZAPATA UGLAND, SEAFORTH HIGHLANDER, and the MOCAN superintendent in St. John's. Post accident investigation of the rig by ROV and divers has been used to recover key components of interest, as well as to perform a comprehensive structural inspection. The following critical chain of events is generally accepted:

- Ballast control room porthole failure
- Ballast control equipment isdisabled
- Forward list develops
- Corrective Ballasting measures are ineffective
- Progressive downflooding into forward chain lockers
- Crew evacuates
- List worsens until capsize

It will never be known what caused the initial forward list. However, post accident investigation revealed that all hull structure was still intact, with the exception of one intermediate column. This was not relevant to the list, and is thought to have occurred as the submerged rig struck the ocean floor. It is possible some valves were opened automatically by the ballast control system as it malfunctioned due to water damage.

It is known that some effort was made to manually activate the ballast control system using the brass actuator rods. This equipment was recovered from the wreck, and the rods were inserted into several of the solenoids for the forward ballast tanks, showing that effort was made to empty these tanks. It is thought that these actions did not improve the deteriorating list condition but actually worsened it; the operators did not have a clear understanding of how the system worked or of the limitations of the system with regards to pumping the forward tanks with a significant forward trim.

Once a certain level of trim developed, the forward freeboard was reduced such that passing waves would swamp the topsides deck. Due to the lack of watertight integrity of the chain lockers, the two forward lockers flooded. As no means was provided to remove water from these lockers, it accelerated the rate of trim by the bow. No alarms were installed in these spaces, so it is unlikely that this particular problem was noticed until it passed the critical stage.

Eventually, the progressive downflooding of the chain lockers and the original source of trim overcame the longitudinal stability of the structure. This is unconventional, as vessels are inherently more stable in the longitudinal direction than in the transverse. Those involved in stability decisions may have neglected the importance of longitudinal stability.

8 DESCRIPTION OF EVACUATION AND RESCUE EFFORT

It is thought that all personnel evacuated the rig. Upon arriving on the scene, and sighting several distress flares, the SEAFORTH HIGHLANDER saw several lights in the water. These were the lights attached to the lifejackets worn by the men. A lifeboat was sighted under power. Both vessels manoeuvred such that that the lifeboat was alongside the port side SEAFORTH HIGHLANDER. Once lines were made fast, the lifeboat capsized as men tried to transfer to the larger vessel. No survivors were recovered. The skipper of the SEAFORTH HIGHLANDER estimated that he saw some 20 men floating in the water, in addition to 36 or so in the lifeboat [1]. During recovery efforts in the following days, 22 bodies were recovered. All were found to have drowned while in a hypothermic state.

Lifeboats 1 through 3 were recovered, but lifeboat 4 was never found. No inflatable life rafts were recovered. Several of the bodies recovered were found submerged, with the life jacket partially slipped off. This is thought to have happened as a result of jumping or being thrown into the water from height; i.e. from the deck of the OCEAN RANGER.

The crews of the three standby vessels all reported that the victims in the water were unresponsive to life rings thrown to them, indicating that hypothermia had already set in.

The helicopter pilots noted that during the darkness of night time, reflective tape on the lifejackets and life boats enabled them to be seen as the searchlights passed over them. However, in daylight, the pilots had trouble identifying anything other than larger debris, including the lifeboats.

9 DISCUSSION OF EVACUATION AND RESCUE EFFORT

Due to the large number of men seen in the water, it is expected that there were issues with getting into the lifeboats and then successfully launching them safely away from the rig. This was partially due to the davit launched design. As the loaded lifeboat was being lowered, it was susceptible to being swung around by the wind and waves. Furthermore, the lifeboats mounted aft likely would have launched directly into the cross trusses, due to the forward trim of the vessel. Concern was also shown due to the fact that the installed lifeboat hooks could only be released under no load conditions.

It is necessary to reconsider the design of lifejackets such that they will not slip off if the user enters the water from height. Furthermore, as the victims in the water showed symptoms of hypothermia, and autopsies of the recovered bodies showed the same results, anti-exposure/immersion suits would have been beneficial. These suits are insulated and waterproof.

Rescue crews noted that victims in the water were unable to help themselves when life rings and other devices were thrown to them. It is possible that if some rescue equipment such as drag nets or hooks were available, crews may have been able to rescue a few survivors. It is noted that one lifeboat was brought alongside the SEAFORTH HIGHLANDER with several survivors onboard. However, there was no safe way to transfer the victims without compromising the stability of the lifeboat. Such designs are intended to have inherent self-righting stability only when occupants are strapped into the seats. Thus as men began to move around, lifeboat capsize was inevitable, and the victims entered the water, accelerating the onset of hypothermia.

Once the sun came up, the helicopter pilots could not see any bodies in the water. Perhaps it would be useful to include other means of high visibility identification to lifejackets to facilitate identification in the daytime.

10 CAUSES

The loss of the MODU OCEAN RANGER was not the result of any one action, but rather a disastrous chain of events. It was the culmination of several minor design flaws and several human factors. It is quite probable that this could have been prevented. The contributing causes of capsize and the subsequent sinking of the OCEAN RANGER are listed below.

10.1 Human factors/errors:

- Failure to deballast from the drilling draft to enhance survivability characteristics
- Lack of understanding of ballast control system
- Lack of understanding of stability concepts
- Lack of experience of the master and junior ballast control operator
- Failure to properly address the listing incident of February 6, 1982

10.2 Operational issues:

- Continuing to drill until the onset of the storm
- The toolpusher was in charge, not the master
- Lack of detailed ballast control procedures in the operating manual

10.3 Engineering/design issues:

- Poor ballast pump placement and/or poor pump selection
- Poor ballast control room placement
- Inadequate porthole in ballast control room
- Lack of watertight integrity of chain lockers
- Lack of water level alarms in chain lockers
- Lack of ability to pump out chain lockers

10.4 Regulatory issues:

- Failure to require person in charge to be licensed/educated in stability

10.5 Loss of Life:

The extent of the loss of life can be attributed to the following factors:

- Capsize of the OCEAN RANGER forced all crew to evacuate
- Lack of anti-exposure/immersion suits
- Inadequacy of davit launched lifeboats
- No means of safely transferring victims from lifeboat to standby vessel
- No means to recover unresponsive victims from the sea in the given sea state

11 RECOMMENDATIONS

After examining this terrible accident, it may be asserted that there is much to be learned with respect to the safety and risk components of offshore structures. Recommendations resulting from the lessons learned are presented below:

- Ensure that all large compartments can be made watertight. Means must be provided to detect water ingress in such compartments. Pumps should be installed to dewater these spaces if/when necessary.

- Design ballast pumping system to effectively work in all combinations of trim/heel conditions. This can be achieved through locating the pumps in a central area, or choosing pumps with sufficient NPSH for all operating conditions.
- Ensure that portholes can withstand design criteria. The load on a porthole 28 feet above the surface in 100 foot waves is significant. Alternatively, implement measures to ensure the deadlight is closed during foul weather so watertight integrity is not jeopardized. If it is necessary to have a visual of the draft marks on each corner column, video cameras or remote sensors could be used.
- Design crucial equipment to have some resistance to water exposure. Ballast control equipment is crucial in a casualty situation, especially one involving flooding. During flooding situations, the ballast control system is much more vulnerable to getting wet. Therefore when the ballast equipment is most needed, it is at higher risk of moisture induced malfunctions, and it should be protected.
- Ensure ballast control operators fully understand how ballast control systems fucntion and the importance of maintaining proper draft and trim from a stability/safety point of view of the whole rig.
- For critical control systems, ensure redundancies (e.g. manual brass actuator rods) are simple devices that are easy to use. Auxiliary control/instrumentation panels would be useful. These should be installed in the pump rooms to facilitate local control of the valves.
- Institute more rigorous training for ballast control operators.
- Conventional monohull vessels typically never experience stability problems in the longitudinal direction. However, due to the arrangement of semi-submersibles, stability in the longitudinal and oblique directions can also be critical. Masters of such vessels must demonstrate knowledge of such conditions.
- Ensure all involved in operations affecting stability are educated in stability concepts.
- Ensure those responsible for maintaining stability are educated in stability and hold some form of mariner certification.
- Investigate ‘close-calls’. It seems there was no formal investigation into the sudden listing on February 6, 1982. If a cause had been determined, a fault in the ballast control system may likely have been identified.
- Continually update the operating manual for the rig. Several off-duty ballast operators knew that there were problems pumping the forward ballast tanks under a forward trim condition. They had developed a few procedures to overcome this problem but had not incorporated them into the manual. As the manual is subject to USCG approval, any safety issues with these procedures would be identified during regulatory review.
- Clarify the regulations for person in charge, such that the toolpusher cannot exert influence over the master in terms of stability and safety of the rig.
- Ensure anti-exposure/immersion suits are carried by all vessels operating in cold water. These suits should have insulating properties and keep the wearer dry to prevent hypothermia.
- Develop alternative to davit launched lifeboats that can be launched in any condition.
- Develop alternate means of rig evacuation into lifeboats.
- Develop life boats with self-righting capability for all load conditions.
- Develop lifeboat release mechanisms that can be released under loaded condition.

- Investigate the slipping characteristics of various lifejackets when the wearer jumps into the water from a great height. If it is found that the lifejacket partially slips off the wearer, develop a new restraining system to prevent so.
- Develop a means to transfer survivors from the small lifeboats to larger standby vessels in rough sea states.
- Develop a means to recover unresponsive victims from the sea in large sea states.
- Implement shorter standby distances for standby vessels.
- Commence disconnecting operations, early before storm conditions, allowing for a time buffer to address any unforeseen events.
- Ensure disconnecting activities commence early enough before the storm to ensure a safe disconnect. This has the added economic benefit of not having to shear off the drill pipe.

Several of these recommendations have already been implemented, but additional work is required in some areas to continue the relentless pursuit of safety in this dangerous industry.

12 CONCLUSION

The capsize of the MODU OCEAN RANGER was a horrific disaster resulting in the loss of 87 lives. However, as a result of various investigations and studies, much has been learned on how to improve the safety of offshore structures. February 15, 1982 will always be remembered as a tragic day for the offshore petroleum industry around the world, as will the legacy of safety improvements brought about by this accident. The safety of the offshore and shipping industries worldwide has benefitted for 30 years due to these improvements, although work remains to be done as we continue to strive for the safest structures possible.

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