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NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

MARINE ACCIDENT REPORT

CAPSIZING AND SINKING OF THE U.S. MOBILE OFFSHORE DRILLING UNIT OCEAN RANGER OFF THE EAST COAST OF CANADA 166 NAUTICAL MILES EAST OF ST. JOHN'S, NEWFOUNDLAND FEBRUARY 15, 1982

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16. Abstract About 0300 on February 15, 1982, the U.S. mobile offshore drilling unit OCEAN RANGER capsized and sank during a severe storm about 166 nautical miles east of St. John's, Newfoundland, Canada; 84 persons were aboard. Twenty-two bodies have been recovered, and the remaining 62 persons are missing and presumed dead. The OCEAN RANGER currently is resting in an inverted position in about 260 feet of water; its value was was estimated at $125 million.

The National Transportation Safety Board determines that the probable cause of the capsizing and sinking of the U.S. mobile offshore drilling unit OCEAN RANGER was the flooding of the anchor chain lockers in the forward columns when it took on a 10° to 15° list in the direction of the severe wind and wave action. The list was a result of the transfer of liquids from other tanks or otherwise filling empty or partially empty forward ballast tanks in the OCEAN RANGER's lower hull after its ballast control console suffered an electrical malfunction from seawater entering through broken portlight(s) and the crew's inability thereafter to manually control the operation of the ballast control system's valves to correct the list. Contributing to the capsizing and sinking was the failure of the management of ODECO to have an effective program to provide sufficient training and familiarization in the operation of the ballasting system to pertinent personnel in the OCEAN RANGER and the failure of the portlight(s) for undetermined reasons. Contributing to the loss of life was: the lack of personal thermal protection equipment for the OCEAN RANGER's crewmembers for the effect of hypothermia; the difficulty of launching lifeboats and liferafts from the OCEAN RANGER in the severe wind and sea conditions; and inadequate equipment aboard the rescue vessels for recovering persons from the sea under adverse conditions.

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Adopted: February 8, 1983

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INTRODUCTION

This accident was investigated jointly by the National Transportation Safety Board and the U.S. Coast Guard. Public hearings were held in Boston, Massachusetts, from April 20 to April 29, 1982, and in New Orleans, Louisiana, from June 7 to June 10, 1982. This report is based on the factual information developed by that investigation. The Safety Board has considered all facts pertinent to the Safety Board's statutory responsibility to determine the cause or probable cause of the accident and to make recommendations.

The Safety Board's analysis and recommendations are made independently of the Coast Guard. To insure that the public is aware of all Safety Board recommendations and responses, all such recommendations and responses are published in the Federal Register.

SYNOPSIS

About 0300 on February 15, 1982, the U.S. mobile offshore drilling unit OCEAN RANGER capsized and sank during a severe storm about 166 nautical miles east of St. John's, Newfoundland, Canada; 84 persons were aboard. Twenty-two bodies have been recovered, and the remaining 62 persons are missing and presumed dead. The OCEAN RANGER currently is resting on the bottom in an inverted position in about 260 feet of water; its estimated value was $125 million.

The National Transportation Safety Board determines that the probable cause of the capsizing and sinking of the U.S. mobile offshore drilling unit OCEAN RANGER was the flooding of the anchor chain lockers in the forward columns when it took on a 10° to 15° list in the direction of the severe wind and wave action. The list was a result of the transfer of liquids from other tanks or otherwise filling empty or partially empty forward ballast tanks in the OCEAN RANGER's lower hull after its ballast control console suffered an electrical malfunction from seawater entering through broken portlight(s) and the crew's inability thereafter to manually control the operation of the ballast control system's valves to correct the list. Contributing to the capsizing and sinking was the failure of the management of ODECO to have an effective program to provide sufficient training and familiarization in the operation of the ballasting system to pertinent personnel in the OCEAN RANGER and the failure of the portlight(s) for undetermined reasons. Contributing to the loss of life was: the lack of personal thermal protection equipment for the OCEAN RANGER's crewmembers for the effect of hypothermia; the difficulty of launching lifeboats and liferafts from the OCEAN RANGER in the severe wind and sea conditions; and inadequate equipment aboard the rescue vessels for recovering persons from the sea under adverse conditions.

INVESTIGATION

There were no survivors from this accident who could provide information regarding the events leading to the sinking of the OCEAN RANGER. The description of events was compiled from the testimony of shoreside personnel who had radio communications (MARISAT, 1/ single sideband (SSB), and very high frequency (VHF)) and personnel on other vessels who had overheard intraship VHF radio communications between persons aboard the OCEAN RANGER.

The Accident

At 1200 2/ on February 14, 1982, the U.S. mobile offshore drilling unit (MODU) OCEAN RANGER was moored in about 260 feet of water on the Grand Banks of Newfoundland, about 166 nautical miles (nmi) east of St. John's, Newfoundland, Canada, drilling an exploratory well for MOBIL Oil of Canada, Ltd. (MOBIL). The 408 foot-long self-propelled OCEAN RANGER, owned by ODECO 3/ International Corporation (ODECO) of New Orleans, Louisiana, was the largest semisubmersible drilling rig in the world. Eighty-four persons, including the toolpusher (person-in-charge), the master, the senior drilling foreman from MOBIL, and the senior and junior ballast control room operators were aboard the drilling unit. Of the 84 persons, 15 were U.S. citizens, 68 were Canadian citizens, and 1 was a British citizen.

Two other MODU's were in the area drilling wells for MOBIL -- the 295 foot-long U.S. MODU SEDCO 706 was located about 8 nmi northeast of the OCEAN RANGER and the 367 foot-long Norwegian MODU ZAPATA UGLAND was located 19 nmi to the north. At 1330 on February 14, NORDCO, Ltd., a commercial weather reporting service, which was under contract to MOBIL to prepare meteorological and oceanographic forecasts for the OCEAN RANGER, forecast that by midnight the drilling unit would experience sustained winds of 70 knots from the west with gusts up to 90 knots and 20-foot significant 4/ waves.

During the afternoon and evening of February 14, there were several conversations via MARISAT among the MOBIL superintendent in St. John's, the MOBIL senior drilling foreman aboard the OCEAN RANGER, the MOBIL senior drilling foreman aboard the ZAPATA UGLAND, and the three MOBIL drilling foremen aboard the SEDCO 706. The MOBIL superintendent testified that at 1357 the OCEAN RANGER senior drilling foreman called and stated that the OCEAN RANGER was "drilling at 18 feet per hour." A few minutes later, the ZAPATA UGLAND drilling foreman called the MOBIL superintendent and stated that the winds were 62 knots and the seas were 27 feet. They discussed procedures for coming out of the hole because of the deteriorating weather and because the ZAPATA UGLAND's drill string [1] 5/ had become "stuck" earlier that morning. At 1545, the ZAPATA UGLAND MOBIL drilling foreman called the MOBIL superintendent again and stated that "they had hung the pipe [2] in the lower pipe ram [3], sheared off the pipe [4], and pulled the pipe out of the hole. The winds were 100 knots and seas were

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1/ An international satellite communications system.

2/ All times herein are Newfoundland standard time (-3 1/2 hours from Greenwich mean time) based on a 24-hour clock.

3/ ODECO is the acronym for Ocean Drilling & Exploration Company.

4/ Significant waves means the average height of the one-third highest waves measured from the trough to the crest of the wave.

5/ Numbers in brackets after words or phrases refer to the glossary in appendix A.

35 feet. They were getting lateral motion of 4° off location [5] and had disconnected the [marine] riser [6]. The [SEDCO] 706 had hung off [7] and their winds were 25 knots and increasing." The ZAPATA UGLAND MOBIL drilling foreman later testified that the ZAPATA UGLAND had deballasted from its 80-foot operating draft to a 75-foot draft on February 15 when it had problems recovering its marine riser.

At 1630, a MOBIL senior drilling foreman in MOBIL's St. John's office called the second MOBIL drilling foreman aboard the OCEAN RANGER via SSB radio. The second MOBIL drilling foreman informed the senior drilling foreman ashore that they were "drilling and would proceed to pull out to hang off [8]" and that they had received the latest weather reports. At 1642, the second MOBIL drilling foreman called back and told the senior drilling foreman ashore that they were hanging off and "the wind was gusting to 70 knots and blowing compensator hoses [9] out the side of the derrick [10]...but he had the situation under control by attaching the air tuggers or air winches to the hose to pull it back..."At 1700, the senior drilling foreman at St. John's called the MOBIL superintendent, who was at home, and informed him that the OCEAN RANGER was hanging off. The MOBIL superintendent testified that the OCEAN RANGER MOBIL senior drilling foreman called him at 1647 with the following information:

> He advised me they had hung off in the middle rams [11], the bit [12] was in the casing [13], sheared the drill pipe with the shear rams [14]. The riser was disconnected and they were riding out the storm. He also advised me that the tensioning ring [15] had hung up once on the spider deck [16] area and at the time of disconnect they were getting 20-foot heaves [17], with spray up into the spider deck area to the rig floor. He advised me the rig lost time with the compensator hoses hanging up in the derrick resulting in not hanging off normally and forced to shear the drill pipes. [He] also advised the storm had built extremely fast during the half hour before disconnecting.

At 1856, the OCEAN RANGER toolpusher called the ODECO drilling superintendent in St. John's via MARISAT. The ODECO superintendent testified that the toolpusher informed him that he "had suspended operation at, they had hung off the drill pipe and sheared the drill pipe and [unlatched] the rod [marine riser] and they were waiting on weather." The ODECO superintendent also testified that the toolpusher said that "he didn't have any problems, everything was going good (sic)."

A MOBIL drilling foreman on the SEDCO 706 testified that, between 1630 and 1900, he entered the SEDCO 706 control room twice and overheard conversations on VHF channel 6 between the OCEAN RANGER toolpusher and the OCEAN RANGER senior ballast control room operator. The toolpusher's transmission was weak while the other voice was clear, and it sounded as though the transmissions came from the OCEAN RANGER's control room. During the first conversation, the toolpusher asked "How was everything," and the senior control room operator replied that, "There was a wet panel in the control room ...that he was working on it and getting shocks off it." The witness stated that he thought the panel mentioned was a gas panel but he was not certain. After hearing the first conversation, the drilling foreman on the SEDCO 706 left the control room and went to the MOBIL office. Shortly afterward, he returned to the control room and overheard a second conversation in which the toolpusher on the OCEAN RANGER again asked how everything was and the senior control room operator replied: "Everything is fine, ...they are mopping up water and picking up glass." According to the MOBIL drilling foreman, "There seemed to be some relief in their voices."

The SEDCO 706 barge engineer testified that about 1900 the SEDCO 706 was struck by one large wave which caused minor damage to its upper deck. After the wave struck, the SEDCO 706 was deballasted from its operating draft of 80 feet to 75-feet. A second MOBIL drilling foreman aboard the SEDCO 706 testified that about 1900 he was in the MOBIL office when the OCEAN RANGER MOBIL senior drilling foreman called him on SSB radio:

> He just called and said that he was attempting to hang off. I suppose he was checking on our status as well, what we were doing at the time and he called and said that he was attempting to hang off but he had got his compensator hoses fouled in the derrick and he was having a problem getting that sorted out and at the same time he mentioned that a window had been knocked out of the control room and there was some water and glass and such.

A third MOBIL drilling foreman aboard SEDCO 706, who was also in the MOBIL office, overhead the same conversation at 1900 and testified that:

> [The OCEAN RANGER] was attempting to pull into the casing to hang off. It was mentioned that their compensator hoses were blowing into the derrick and hanging up...That the [control room] window had been knocked out. There was no problem, they had some water to mop up and I believe he said everything is okay.

Beginning about 1945, the SEDCO 706 barge engineer and the control room operator, both of whom were in the control room, overheard broken-up radiotelephone conversations on VHF radio channel 6. They recognized the voice as that of the OCEAN RANGER's junior control room operator. The SEDCO 706 control room operator testified that he overheard: "We have water and glass on the floor....all valves are opening on the portside," and after a short time, "it seems okay now." The barge engineer overheard, "Water on floor, everything secure...Gas detection panel knocked out...PA system knocked out...getting electrical shocks."

The MOBIL superintendent testified that at 2044 he received the following communication via MARISAT from the MOBIL senior drilling foreman on the OCEAN RANGER:

> [He] advised me they had 50-foot plus maximum combined seas and winds in the 90/100-knot range. He advised me that one wave had taken a window out of the barge control room. He advised me there was no problem with this window outting and from memory he advised me that all that was required was to mop up a little bit of water in the room and that all of the equipment was functioning properly at that time. He advised me that the anchor tensions [18] were all in the 240,000 range. Also that the barometer had leveled off, everything was normal at the rig. They had no problems.

About 2100, the SEDCO 706 barge engineer overheard the following conversation on VHF channel 6: "valves or valve are opening on their own, ET [electronic technician] requested to the control room." About the same time, the SEDCO 706 control room operator overheard: "We need a EL technician down here. We have positive electric shock in the panel." He also overheard the OCEAN RANGER asking the SEAFORTH

HIGHLANDER, the OCEAN RANGER's standby boat, 6/ "How far are you away from the rig" and the standby boat replying "7 miles away" At 2145, the barge engineer overheard, "Everything seems to be okay down here, we are cleaned up and normal," while the control room operator overheard, "everything is okay."

Between 2130 and 2230, the master of the BOLTENTOR, the SEDCO 706's standby boat, overheard a broken transmission on VHF channel 6, lasting 5 to 10 minutes. He testified as follows:

> At about the mid[dle of the] watch [2130 to 2230]. I cannot place it any closer than that, we heard some conversations on what I took to be hand-held VHF sets, walkie-talkie, to the effect that or initially establishing contact. Can you hear me; yes I can hear you now, whatever. And then a voice said, "Well, there is broken glass in here and there is water in here" and another voice said, "I will get it cleaned up, get some guys in there and get it cleaned up." Then another voice yet, a third voice, said, "Well, there is some high-powered cables down there." And the second voice came back and said, "Well, don't have anybody injured or killed, but obviously still get the water cleaned up." And the last thing I heard was another voice saying, "Well, there is some valves operating or opening or closing." I can't remember the exact words, but it was to do with valves operating.

The MOBIL superintendent testified that at 2200:

> I received a call from the OCEAN RANGER [MOBIL senior drilling foreman], as requested previously, to inform me of the status of the other two semisubmersibles. On the OCEAN RANGER, he advised me the maximum combined seas were in the 55-foot, the odd wave going up in the 65-foot range. I asked [him] if he was having any problems in the barge control room with the window being taken out, and he assured me that all of the equipment was functioning normally. On the UGLAND, he advised me they had lost one guide line, that the winds were in the 80-85 knot range, maximum combined seas in the 34-55 foot and some higher. The SEDCO 706 had disconnected and they had the thrusters on 75 percent power. I do not have it noted nor can I remember which call, but I was aware, which is normal procedure, that once the rigs have disconnected the riser they will deballast the rig up five to ten feet to gain more air gap [19] and also to lessen the chance of seas breaking on the main-deck level. I ended my conversation with [him] with us both in agreement at that time that the rigs were all riding out the storm with no problems, and he indicated that the wind and the seas had come down slightly from what they had been previously. All that we could do was ride the storm out for the night and I would talk to them in the morning.

At 2330, the MOBIL radio operator in St. John's received a routine weather report from the weather observer aboard the OCEAN RANGER. The weather observer did not discuss any other matters nor indicate that there were any problems on the OCEAN RANGER. The next known communciation from the OCEAN RANGER was at 0052, when

6/ Each MODU operating off the coast of Newfoundland had, at all times, a vessel stationed nearby to provide assistance in case of an emergency on the MODU.

the radio operator on the SEDCO 706 received a distress message on 2182 kHz 7/ SSB from the OCEAN RANGER radio operator stating the OCEAN RANGER's position, that it had a severe list, and that it required immediate assistance. At the same time, the MOBIL senior drilling foreman on the OCEAN RANGER called the radio operator on the SEDCO 706 on MOBIL Channel 1 SSB and requested that the SEDCO 706 broadcast a distress message on behalf of the OCEAN RANGER and stated that the OCEAN RANGER had a severe list. The SEDCO 706 radio operator stated that the OCEAN RANGER continued to broadcast a distress message "every couple of minutes...until 0500 Zulu [0130, February 15] when they [the crew of the OCEAN RANGER] went to liferaft stations."

The MOBIL superintendent testified that:

> 0100 hours, one or two minutes either side as I had just glanced at my watch, I received a [MARISAT] call from the OCEAN RANGER, [MOBIL senior drilling foreman.] He was calling to request me to alert the [Canadian] Coast Guard. The OCEAN RANGER was listing to the bow eight to ten feet which I am sure is degrees. I did not question him on it. They had 75- to 80-mile-an-hour winds. They were attempting to isolate the problem. They did not know what the problem was.
>
> The stand-by boat was the HIGHLANDER. I did request from [him] how many people were on board, and he advised me of 84 men on board. [He] at this time was cool, calm and collected. I recognized from the tone of his voice and from the information he had given me that they had a serious problem. I advised him that I would have work boats on the way to him and that our helicopters would be activated and that I would proceed to the office and that is where he would be able to get in contact with me next.

The master of the SEAFORTH HIGHLANDER, testified that normally his position was 1 to 2 nmi away from the OCEAN RANGER, but because of the severe weather conditions, at 0105 his position was about 8 nmi south of the OCEAN RANGER and that:

> At that last time, 0105 hours on the 15th of February, the OCEAN RANGER called up the SEAFORTH HIGHLANDER again on Channel 6 VHF and asked the HIGHLANDER if she would come in a little closer. I'll try to remember his exact words for you. He said, "SEAFORTH HIGHLANDER, will you come in a little closer, please?" He said, "We've got a problem here on the rig," and I said, "Yes, certainly I'll start coming in closer now." I said, "Would you like to discuss this problem with me? He said, "Stand by," and approximately half a minute later he came back on the radio and he said "Yes. We have a list" or, "We are listing to port and all countermeasures are ineffective, so if you could come in close as soon as you can make it," and I said, "Right. I'm on my way. We are coming in now," and that was the end of my communication with the OCEAN RANGER and in fact that was the last communication I ever had with the OCEAN RANGER.

* * * * *

7/ The international high frequency radiotelephone distress frequency.

> At 0110 hours I overheard on VHF Channel 6 the OCEAN RANGER calling the SEDCO 706. SEDCO 706 immediately replied, and the OCEAN RANGER advised the SEDCO 706 to send out a mayday relay regarding OCEAN RANGER immediately. SEDCO 706 questioned this by saying, "You want me to send out a mayday relay now?" The OCEAN RANGER said, "Yes, send it out now, and if you try calling us back afterwards and don't get any reply from us, then you know we have already taken to the lifeboats."
>
> I believe the SEDCO 706 said something like, "Okay. I'll send it out now," and that was the end of that transmission. Immediately we overheard on 2182 kHz the mayday relay being broadcast by SEDCO 706 for the OCEAN RANGER. He broadcast that message immediately afterwards. He was very very quick to do it. At this time the SEAFORTH HIGHLANDER was on full maximum speed heading in to the OCEAN RANGER.

At 0109, a MARISAT operator received a distress telex message from the OCEAN RANGER radio operator, "Are experiencing a severe list unable to correct problem." The MARISAT operator connected the OCEAN RANGER with the U.S. Coast Guard Rescue Coordination Center (RCC) in New York at 0112 and the following telex message 8/ was received:

> WE ARE THE ODECO OCEAN RANGER KRTB LOC 46.43.33N 48.50.13W AND ARE EXPERIENCING A SEVERE LIST OF ABOUT 10-15 DEGREES AND ARE IN THE MIDDLE OF SEVERE STORM AT THE TIME 12 DEGREES AND PREGRESSING. MREQUEST ASST ASAP. MWEL ARE AN OFFSHORE DRILLING PLATFORM. MIDWINDS AT THIS TIME ARE APPROX FROM THE WEST AT APPROX 75 KNOTS. RIG IS OF SEMI-SUBMERSIBLE BUILD AND IS LISTINC SEVERELY 12-15 DEGREES TO THE PORT SIDE. M GENL INFO

At 0121, the RCC in New York notified the Canadian Coast Guard RCC in Halifax, Nova Scotia, by telephone which, in turn, notified the Canadian Rescue Unit at Gander, Newfoundland, at 0131. The MARISAT connection between RCC New York and the OCEAN RANGER was broken at 0130; 13 attempts by the MARISAT operator between 0131 and 0256 to reestablish the telex connection were unsuccessful.

The MOBIL radio operator in St. John's testified that:

> At 10 after 1 the OCEAN RANGER radio operator called [on SSB]. I forgot the exact words he used, but he advised that he had a mayday, they were listing badly and were to notify Search and Rescue and the 706 picked up the message at the same time and he began to put out a mayday on 2182 and I called the Coast Guard at St. John's Search and Rescue on the telephone and advised them.
>
> The drilling foreman came on with him, almost like together, they have the radios in the radio room and they have what you would call an extension in the foreman's office. So, I am not sure if he was in his

8/ This message is quoted exactly as received by RCC New York including misspellings and other errors.

office or they were both on there in the radio room, but the foreman came on and he just repeated they had a mayday and the rig was listing badly and that they were going to want to evacuate.

I had Search and Rescue on the phone between 1:10 and 1:30 and phone patched them into the OCEAN RANGER. The contact wasn't very good. I believe they could hear the OCEAN RANGER fairly well, but he couldn't hear them too good. They didn't give any details at all. They just said they were listing badly, wanted to evacuate and they wanted three or four helicopters, Chinooks to come out and take them off.

The third MOBIL drilling foreman on the SEDCO 706 stated that at 0115, the MOBIL senior drilling foreman on the OCEAN RANGER called on SSB "and asked or requested that I send my standby boat and also arrange to have the one from UGLAND sent over as he was about a 12 degree list forward, he told me and if I could forward the boats to him." The first MOBIL drilling foreman on the SEDCO 706 testified that about 0115 the OCEAN RANGER MOBIL drilling foreman called on SSB and said, "the rig was at a list, developed a list, and was listing, seemed to be stabilized at about 10 degrees and that there were, they were trying to isolate the problem and doing what they could to correct the problem....the bow was down." The third MOBIL drilling foreman on the SEDCO 706 then told the SEDCO 706 barge engineer to direct the BOLTENTOR and the NORDERTOR, the ZAPATA UGLAND's standby boat, to assist the OCEAN RANGER. At 0120, the barge engineer, using VHF channel 6, dispatched the BOLTENTOR and called the ZAPATA UGLAND on VHF channel 12 to have the NORDERTOR proceed to the OCEAN RANGER.

The master of the BOLTENTOR, which was about 1 nmi south of the SEDCO 706, stated that about 0100 the BOLTENTOR's second officer, who was on watch, became aware that the OCEAN RANGER was "possibly having difficulties" and that at 0115 he woke the master. The BOLTENTOR proceeded toward the OCEAN RANGER and when it was about 6 nmi away at 0125, it was informed of the urgency of the situation and increased speed. However, because of the sea conditions, the BOLTENTOR made less than 6 knots. At 0130, when the NORDERTOR was about 2 nmi north of the ZAPATA UGLAND, it was cleared by the ZAPATA UGLAND to proceed to the OCEAN RANGER and assist.

The master of the SEAFORTH HIGHLANDER stated that the seas were terrible. Although the vessel was rolling and pitching violently as it proceeded through a driving snowstorm toward the OCEAN RANGER, it was able to make 10 to 10.5 knots. About 0150, the SEAFORTH HIGHLANDER was 0.2 nmi downwind of the OCEAN RANGER. The master said "he could see the rig apparently illuminated as normal...but could not tell if the rig was listing" because of the SEAFORTH HIGHLANDER's motion. The master testified as follows—

0150 hours, and almost immediately at that time we observed small lights in the water approximately four, five points on the starboard bow, and we sighted a red distress flare approximately four points on the starboard bow at the same time. I proceeded towards the red distress flare, and while proceeding to it another flare from the same source went up. Probably about three minutes after sighting the first flare we visually sighted a lifeboat which at first appeared to be in good shape riding high on the water, and I maneuvered my ship very close downwind of the lifeboat. The lifeboat was under power because he steamed across a swell, across my stern from starboard side to port side, and he maneuvered his lifeboat down the port side of my vessel on to the port quarter. He came alongside us, and my men, who by this time had gone out on the deck, threw lines to the lifeboat, lines with liferings attached. One line was made fast on the lifeboat, and the other ring was made fast to my ship. Then some men began to come out of the enclosed boat, and they stood on the port side of the lifeboat, which was the side away from my vessel —four or five, maybe six men came out and stood on the port side.

Sometimes the lifeboat was just touching the SEAFORTH HIGHLANDER but not especially violently. At other times she was about six feet off the SEAFORTH HIGHLANDER. She was moving in and out a little. It was at that time that the lifeboat began to capsize to port in a very slow manner, like watching a slow motion picture. The men standing on top of the boat were thrown into the sea. The boat remained capsized. I believed during the capsize of the lifeboat the line we had made fast to it parted. After it had capsized it was approximately 12 feet maybe off the SEAFORTH HIGHLANDER, and I could see what I estimate to be eight or nine men clinging to the boat in the water. I could see all these men. They had lifejackets on, and there was a light on each lifejacket.

At about this time I was taking heavy seas in the after deck of my vessel which was stern to wind and sea. The mate and one of the seamen were washed up [on] the deck, but they were both okay, although they suffered some bruising. The gangway net was washed over the side. We were still along the lifeboat, and after maybe a minute and half or two minutes —it is very difficult to estimate — the men clinging to the boat began to let go, and they drifted down my port side. At that point I shouted down to the mate on the deck via the loud hailer system to throw over a liferaft. I saw the men running up forward on my deck to go for the liferaft, and they threw a liferaft over the side which inflated right beside the men in the water. No effort was made by any man in the water to grab hold of the liferaft. No effort was made by any of the men in the water. No apparent effort was made by any of the men in the water to reach the lines which my men had been throwing to them after the boat capsized.

I saw a lifering with line attached landing close to the men clinging to the boat, and they didn't make any effort to reach the lifering. At this time there were some men drifting down my port side, but the lifeboat was still off the port quarter of the ship with two or three men clinging to it. It was close to my port propeller at this time, so I had to stop my port propeller in case the men got caught in it.

At that time the SEAFORTH HIGHLANDER was forced off the location by the heavy seas, and we could no longer maintain our position alongside the men in the water or the lifeboat. Once we were clear of all the men I was able to use the port propeller again, and I maneuvered the ship back around to an upwind position from the lifeboat and steamed down close to the lifeboat, the men and the lifejackets in the water. There was no sign of life at all. We could see all the men floating with their heads under the water, some of them with their arms outstretched, no sign of life, and the men on the deck were trying to pick up bodies. We couldn't get close to any of the bodies. It was very difficult. We were washing the bodies away with the motion of the ship, and for the rest of that morning we kept searching that area for any live personnel which might have been found.

We saw many bodies in the water, bodies which had obviously not come from the lifeboat which had capsized alongside us, but there were no signs of life at all.

Meanwhile, the BOLTENTOR was approaching the OCEAN RANGER from the starboard beam. About 0230, when the BOLTENTOR was 0.3 nmi away, the master of the BOLTENTOR sighted only two lights on the OCEAN RANGER. He stated, "to the forward end of the rig there was one small white light, fairly low down near the water and at the aft end I saw one large greenish tinged light....whether the rig was tilted forward or not, I couldn't say." However, two BOLTENTOR deckhands testified that they saw three lights and that the OCEAN RANGER had about a 35° list, but they were not able to determine the direction of the list. About 0245, the BOLTENTOR proceeded around the starboard quarter of the OCEAN RANGER to within 0.1 nmi and its searchlight was used to illuminate the drilling unit. The master stated, "...the rig appeared to be upright...there were no flag [flood] lights, no contact on radio, and there was nobody visible in our searchlights." About 0255, the master of the SEAFORTH HIGHLANDER called the BOLTENTOR. The master of the SEAFORTH HIGHLANDER said that the SEAFORTH HIGHLANDER was about 1.5 nmi downwind, that they were alongside an overturned lifeboat, and that there were bodies in the water; he requested the BOLTENTOR's assistance. The BOLTENTOR got underway at full speed and proceeded to the location of the SEAFORTH HIGHLANDER. The crew of the BOLTENTOR never saw the OCEAN RANGER again.

At 0130, when the NORDERTOR departed the vicinity of the ZAPATA UGLAND it was about 20 nmi north of the OCEAN RANGER. The master of the NORDERTOR stated that, when the NORDERTOR was 13 nmi away, he "picked up the OCEAN RANGER and the two other supply vessels" on radar. He stated that he observed the contacts on his radar for about 1/2 hour until the NORDERTOR was 6 or 7 nmi away, at which time, the OCEAN RANGER contact disappeared from the radar screen. The master stated, "First there was nothing and then there was (sic) a couple of small blips in the same area and that's all we had, the last of the radar contact we had." At 0340, the NORDERTOR arrived about 2 nmi north of the OCEAN RANGER's location and began to search downwind of the OCEAN RANGER's position.

All three vessels continued to search for survivors during the night and into the next day. At 0700, the NORDERTOR found an overturned lifeboat with a lifering from the SEAFORTH HIGHLANDER attached to it. The master of the NORDERTOR stated that while they were attempting to tie a line to the lifeboat, seven or eight bodies emerged from a large hole in the bow of the boat. The master said that after the line was attached to the lifeboat, he saw " several bodies there strapped in by the seatbelts they have in the boat. I would say a rough number of maybe 20." In attempting to recover the lifeboat, the line became caught in the NORDERTOR's propeller, and the lifeboat broke loose. While the crew of the NORDERTOR freed its propeller, the lifeboat drifted away. The master stated, "We were going to search again for that boat, but we got a call from the aircraft search and rescue there to proceed to some liferafts with possible life onboard." The lifeboat has never been recovered.

Injuries to Persons

Injuries	Crew	Others	Total
Fatal	84	0	84
Serious	0	0	0
Minor/None	0	0	0
Total	84	0	84

Damage to Vessel

The OCEAN RANGER sank upside down, with its bow on a heading of 117° in about 260 feet of water about 150 yards southeast from its anchored position over the wellhead and is resting on the bottom. Underwater videotapes of the sunken drilling unit were taken in early March 1982 by an unmanned submersible. The videotapes showed minor damage to the bows of both lower hulls, two broken portlights in the control room, and that all four deadlights were closed. The videotapes did not show any other major structural damage to the OCEAN RANGER's columns or lower hulls. A side scan sonar survey, conducted between February 18 and March 2 1982, located drill pipe and other debris scattered up to 300 yards from the sunken drilling unit in a northwest to southeast direction. The value of the drilling unit was estimated at $125 million.

Crew Information

Pursuant to the contract between ODECO and MOBIL, ODECO provided the OCEAN RANGER with 38 drilling personnel, including the toolpusher, the master, 2 control room operators, and 2 radio operators. ODECO also provided all hotel services, including food catering. MOBIL provided all other support services, equipment, supplies, and personnel, including all marine and air transportation to and from the drilling unit, a standby vessel, and weather forecasting and diving services.

At the time of the accident, 84 persons were on board the OCEAN RANGER. Forty-six persons, including fifteen United States citizens, were employed by ODECO Drilling Company of Canada, the operator of the OCEAN RANGER. Each person aboard the drilling rig, except for the toolpusher and the master, worked a 21-day "tour," which included 12 hours on duty and 12 hours off duty, and then each was off duty for 21 days. The toolpusher and the master were on call continuously.

The majority of the key positions—such as toolpusher, master, assistant toolpusher, subsea technician, mechanical/electrical supervisor, senior control room operator, senior electrician, rig mechanic, crane operator, and industrial relations representative (IRR)--were held by U.S. citizens. U.S. Coast Guard (USCG) records indicated that the rig mechanic and the crane operator were documented as ordinary seamen; ordinary seamen are not normally eligible to be certificated as lifeboatmen. Canadian citizens employed by ODECO held other key positions--radio operator, electronic technician, junior control room operator, motorman, and medic.

The remaining persons aboard the OCEAN RANGER at the time of the accident were either MOBIL employees or MOBIL subcontractors who provided support to MOBIL in the area of well testing, geology, diving services, and weather observations. Two MOBIL drilling foremen provided technical oversight for the drilling operation.

The toolpusher, 36, was a resident of Mississippi. He was designated person-in-charge by the OCEAN RANGER's operating manual. During his employment with ODECO, he had served on numerous drilling units and had previously worked on the OCEAN RANGER as the assistant toolpusher under the ODECO drilling superintendent. He had been toolpusher on the OCEAN RANGER since January 1981.

The master, 58, was a resident of Maryland. He possessed a valid U.S. Coast Guard license as unlimited master and had sailed on tankers and tugs before being employed by ODECO on March 31, 1981. He had served on the MODU OCEAN VICTORY and the MODU OCEAN BOUNTY before becoming the master on the OCEAN RANGER on January 26, 1982.

The senior MOBIL drilling foreman had been employed by MOBIL for about 2 years. His previous drilling experience had been as a toolpusher with another drilling company.

The senior control room operator, 30, had been employed by ODECO, since January 19, 1980. Before he began serving as a control room operator, about 2 months later, in March 1980, he had served as a roustabout, the entry level of industrial employment aboard a drilling rig. The junior control room operator, 29, had been employed by ODECO since December 22, 1980. Before he began serving as a control room operator in December 1981, he had served as a roustabout.

The industrial relations representative, 29, was responsible for safety conditions and crew training on board the OCEAN RANGER; he reported directly to the ODECO Director of Safety and Training in New Orleans, Louisiana. A Vice President of ODECO testified that the IRR was responsible for helping the toolpusher read and understand USCG regulations. The following information was excerpted from the duties published by ODECO in the spring of 1979:

1. Sign in all personnel and insure that all new hands and visitors are properly indoctrinated. Maintain personnel log.

* * * * *

7. Check firefighting and lifesaving equipment weekly. Repair, replace and maintain all firefighting and lifesaving equipment to U.S.C.G. standards.

8. Conduct drills of all types per prescribed schedules. Fire and Abandon [ship] drills are to be held weekly.

* * * * *

21. Check pollution equipment daily. See that they are properly maintained and working.

* * * * *

Vessel Information

Operation.--The self-propelled, twin hull, eight-column semisubmersible OCEAN RANGER (see figure 1) entered into service in June 1976 as a Panamanian registered MODU. At the time, it was the largest semisubmersible drilling rig in the world. The

Figure 1.--The U.S. Mobile Offshore Drilling Unit OCEAN RANGER.

OCEAN RANGER was designed by ODECO Engineering in New Orleans, built by Mitsubishi Heavy Industries in Hiroshima, Japan, and classed by the American Bureau of Shipping (ABS). (Appendix B contains detailed information concerning the OCEAN RANGER's characteristics and tank capacities.)

The OCEAN RANGER was designed to operate at a drilling draft between 45 and 80 feet and in waters up to 3,000 feet deep. However, at the time of the accident, the drilling rig was outfitted with a mooring system that limited its drilling depths in water to 1,500 feet. The combined wire rope and chain mooring system consisted of twelve 45,000-pound anchors, three at each corner column. Each anchor was joined to 1,600 feet of 3 1/4-inch chain and 4,500 feet of 3 1/2-inch wire rope for a breaking strength of about 1,200,000 pounds. The working load for wire rope and chain of this size is about one-third of its breaking strength, or 400,000 pounds, and its test tension is about 800,000 pounds.

The purpose of the mooring system is to maintain the position of the drilling unit over the wellhole. If the drilling unit cannot maintain its position over the well, it must disconnect. The OCEAN RANGER's Emergency Procedures Manual states, in part:

> There are Three Phases of the Heavy Weather Policy:
> Phase 1 - Stop drilling operations and hang off drilling string
> Phase 2 - Disconnect the Marine Riser
> Phase 3 - Evacuation of Drilling vessel
>
> PHASE 1 - HANGING OFF
>
> As a general rule, if any of the following criteria are reached, drilling operations will be suspended and the drill string hung off in the well head:
>
> (1) Vessel motions are/or prevailing weather conditions are such that it becomes difficult and/or hazardous to personnel to make connections.
>
> (2) The significant heave of the rotary table reaches 6 feet and/or maximum heave reaches 10 feet.
>
> (3) The maximum angle of the lower ball joint reaches 4 degrees.
>
> (4) The mean line tension of the highest loaded anchor reaches 75 percent of the test tension.
>
> PHASE II - DISCONNECTING
>
> The consequences of disconnecting too late or not at all can be disastrous. On the other hand disconnecting too early will result in a loss of drilling time. In the long run this loss is not as expensive as the cost for replacing the riser system.
>
> The marine riser should be disconnected from the B.O.P. [blowout preventer] stack whenever the following criteria are reached, or whenever the Operator Toolpusher or ODECO's Toolpusher has reason to believe they will be reached and/or exceeded in the near future.

(1) The significant heave of the rotory table reaches 8-10 feet and/or the maximum heave reaches 15 feet with an expected further deterioration of the weather.

(2) The maximum angle of the lower ball joint approached 10 degrees.

(3) The mean line tension of the highest loaded anchor reaches half of the chain/cable break strength.

NOTE: In good holding ground the anchors may be able to hold considerably more than the test tension which is limited by the pull available at the winches.

NOTE: After having experienced a bad spell of weather, consideration should be given to pulling the marine riser and checking it for cracks prior to continuing the drilling operation.

PHASE III - EVACUATION

It should be noted that ODECO's Toolpusher is responsible for any decision to abandon the rig.

For any storm with forecast winds of 100 m.p.h. or more, consider evacuation of personnel and act as follows:

1. Confirm forecast, alert Contractor's Shore Base Manager of environmental condition.

2. Request additional forecast from appropriate Weather Center for rig location at 3 hour intervals.

3. Review the present and past sea conditions to determine it they are rising or falling and to determine what effect the storm is likely to have on the sea conditions.

4. Determine if sea and wind conditions will permit a safe evacuation.

5. Determine if evacuation is necessary or possible.

6. Discuss with Contractor's Shore Manager, and mutually decide if evacuation is necessary or possible.

7. Review procedure for rig evacuation with Barge Master.

8. Prepare rig for total evacuation.

9. Check on availability of tug boats.

10. As conditions warrant

    (i) Evacuate nonessential personnel
    (ii) Evacuate all personnel except skeleton crew
    (iii) Complete evacuation

Although the OCEAN RANGER was a self-propelled vessel, when anchoring it was necessary for anchor handling vessels to position the drilling rig's anchors and to raise the anchors before a move. All fuel, drilling water, drilling mud, provisions, and drilling material were delivered to the drilling unit by supply vessels.

Stability.-- The OCEAN RANGER was designed to meet the stability requirements for a column stabilized drilling unit contained in the ABS "Rules for Building and Classing Offshore Drilling Units - 1973." (See appendix C.) It first was required to meet the U.S. Coast Guard stability requirements contained in 46 CFR Subchapter I-A, Mobile Offshore Drilling Units when it came under U.S. Coast Guard inspection in 1979. (See appendix D.) Included in both standards were requirements that the OCEAN RANGER:

(1) Be able to withstand the overturning moment of a steady 70-knot wind from any direction;

(2) Have the capability at all times to change its loading condition to withstand the overturning moment of a steady 100-knot wind;

(3) Be able to withstand the flooding of those watertight compartments which extend within 5 feet of the drilling unit's draft; and

(4) Have an operating manual.

The 1979 Inter-Governmental Maritime Consultative Organization (IMCO) (now International Maritime Organization (IMO)) Code for the Construction and Equipment of Mobile Offshore Drilling Units contained similar requirements. The OCEAN RANGER's operating manual contained the additional owner-imposed requirement that "the unit have at least 1.5 feet positive GM 9/ in all directions, after correction of KG [vertical center of gravity] for free surface, in all operating and safety conditions."

A former senior control room operator, who had worked on the OCEAN RANGER for 5 1/2 years before November 1981, testified that if an operator made a mistake, it would take only a few minutes for the drilling unit to take on a 5° to 10° list. The former operator stated that:

> During probably the first year I was on board, somebody dropped a bunch of drill water from the drill water day tank to Starboard 5, I recall that being 5 degrees before we got it back. A couple of other times somebody opened a valve the wrong way and got about 4 or 5 degrees on it.

He further testified that he had instructed the senior control room operator, who was aboard on February 15, to close all valves if there was a ballast problem. He stated that it was his practice to maintain the after ballast tanks only about 75 percent full for the purpose of counterflooding in case of an unexpected list.

The chain lockers could flood through the three 6-square foot (ft^2) chain pipe openings and three 25-ft^2 wire rope trunk openings on the top of each of the four corner columns. Only the chain pipe openings are shown on the damage control plan in the operating manual; the wire rope trunk openings are not shown in the manual. The Manager of ODECO's Design Division testified that the upper hull of the OCEAN RANGER was of watertight construction for about 30 feet inboard from its periphery.

9/ GM is a measure of a vessel's ability to withstand overturning forces.

In addition to meeting the damage stability requirements of USCG and ABS, ODECO designed the OCEAN RANGER to survive damage to one chain locker, one propulsion room, one pumproom, or one of the void spaces located below the after columns in the lower hulls or individual void cross members while at the 80-foot operating draft. To meet this design requirement, the OCEAN RANGER's operating manual required that ballast tanks PT-2, PT-3, ST-2, and ST-3 were to be kept at least 42 percent full; ballast tanks PT-15 and ST-15 were to be kept at least 12 percent full; and drill water tanks PT-5 and ST-5 were to be kept at least 13 percent full. (See figure B-1, appendix B.)

The operating manual also suggested that, at the 80-foot operating draft, PT-8, PT-9, ST-8, and ST-9 should always be kept empty; PT-10 and ST-10 should be kept empty, if possible; PT-4 and ST-4 should be kept between 73 and 100 percent full; and PT-7 and ST-7 should be kept between 86 and 100 percent full. However, an experienced former master stated that it was the practice aboard the OCEAN RANGER to carry ballast in PT-8, PT-9, ST-8, and ST-9.

The operating manual provided no guidance on how to prevent flooding into the chain lockers from wave action if a large list occurred, nor gave any guidance on how to pump out the chain lockers if they were flooded. A former control room operator testified that a portable submersible pump aboard the drilling unit could be used for pumping out the chain lockers.

The operating manual stated that, under certain loading conditions, the OCEAN RANGER could "possibly tend to take up a permanent list or trim under the action of large, steep waves." The Manager of ODECO's Design Division testified that a statement to this effect was added to the OCEAN RANGER's Operating Manual as a result of model tests 10/ conducted on generic MODU hulls by the Society of Naval Architects and Marine Engineers (SNAME). The generic hull, similar in design to the OCEAN RANGER's, at a 70-foot draft and a GM of 5 feet exhibited a mean heel angle of 4° with regular 32-foot beam seas. On February 15, the OCEAN RANGER was at an 80-foot draft with a transverse GM of about 6 feet and a longitudinal GM of about 4 feet. However, the SNAME study notes that real seas are random, rather than regular, and that the randomness of a sea state precludes the existence of a steady wave induced heel. Instead, in real seas, a MODU may experience an occasional rolling oscillation of long duration.

History.--Between June 1976 and September 1977, the OCEAN RANGER was drilling in the Gulf of Alaska where it experienced four storms with maximum winds exceeding 65 knots; however, the maximum wave heights in each storm were less than 20 feet. From September 1977 to July 1979, the drilling unit remained in an idle status in the Gulf of Alaska. In July 1979, the OCEAN RANGER was moved to a shipyard at Port Alberni, British Columbia, Canada, where it underwent repairs. At the same time, ABS representatives conducted an underwater inspection in lieu of drydocking; special survey No. 1 of the hull, machinery, and electrical apparatus; an ABS annual survey of the hull and machinery; and an annual load line inspection. No outstanding requirements were noted as a result of the inspections.

On August 5, 1979, the OCEAN RANGER departed Port Alberni under tow for the east coast of the United States by way of Cape Horn. On October 5, 1979, ODECO requested inspection and U.S. certification and registry from the U.S. Coast Guard. In December 1979, the drilling unit arrived in Davisville, Rhode Island, where an inspection

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10/ "Assessment of Stability Requirements for Semisubmersible Units" Numata, Michel and McClure, Transactions 1976.

was conducted by the USCG Marine Inspection Office in Providence, Rhode Island. On December 27, 1979, the USCG issued a Certificate of Inspection and documented the OCEAN RANGER as a U.S. registered vessel. However, the USCG noted that the following items were to be completed before the next inspection (December 1981):

1. Comply with 46 CFR 108.506 davit launched liferafts or acceptable substitute.

2. Replace lifeboats and davits with CG approved or obtain approval for existing ones.

Between January and May 1980, the OCEAN RANGER operated off the east coast of the United States. During this time, it did not experience any storms with winds over 65 knots. On May 29, 1980, the drilling unit departed under tow for Ireland, where it experienced a storm while in the drilling mode on October 6 and 7 with 70-knot maximum winds and 40-foot maximum waves. The OCEAN RANGER departed Ireland under tow on October 10 and arrived off the coast of Newfoundland on November 6, 1980. Between its arrival and sinking, the OCEAN RANGER experienced only one storm with maximum winds over 65 knots from January 16 to January 22, 1982. The winds were 50 knots gusting to 70 knots, and the waves were 28 feet with a 47-foot maximum wave height; the MODU was in the drilling mode.

On February 6, 1982, the OCEAN RANGER "incurred a 5 to 5 1/2-degree list and that was quite out of the ordinary" according to the alternate junior control room operator (operator) who was aboard the rig at the time. According to the operator, about 0400, the OCEAN RANGER had been taking on fuel and drilling water. At 0600, the master, who was still aboard on February 15, relieved the operator so that he could go to breakfast. When the operator returned to the control room, the master told him that the fueling had been completed and directed him to close the fuel oil manifold valves in the starboard pumproom. While proceeding to the pumproom, the operator noticed a list as he was descending in the elevator, and by the time the elevator reached the lower hull, the list had become quite significant. He quickly closed the fuel oil valves and returned to the control room where he found the senior control room operator, who was still aboard on February 15, at the control panel correcting the list while the master was standing nearby. After the list was corrected, the toolpusher called the master and the operator to his office, where after some discussion, the master, according to the operator, told the toolpusher, "I think the best thing to do here is for me not to operate the console," and the toolpusher replied, "Yes, I think so." According to the operator, the master did not explain what caused the list, but the senior control room operator told the operator:

> It looked as though the sea chest valve had been left open and he had been flooding Port 14....And it looked further when he went to correct it, to pump out, he did have a pump on it, but he still had the sea chest valve open, so there was flooding going on at the same time.

The operator stated that he believed the master "did not intend to touch that console for quite awhile." A former ballast control room operator, who had worked on the OCEAN RANGER for 5 1/2 years, stated that the remote controlled sea chest valve on the portside was frequently kept open when using the smaller auxiliary sea water pump to keep the upper hull sea water tank filled.

The ODECO drilling superintendent, who happened to be aboard at the time, stated that, when the list occurred, the IRR announced over the public address system that the crewmembers should go to their lifeboat stations. The drilling superintendent questioned the IRR about the announcement because he did not believe the IRR had the authority to announce evacuation. According to the drilling superintendent, the IRR replied that he thought that was the thing to do. The drilling superintendent stated that the master had accidentally opened two ballast tanks to the sea, creating the list and that afterward the toolpusher told the master, "You do not go in there [control room] alone, or without the ballast control room operator." In a written report dated February 11, 1982, and received by the MOBIL superintendent in St. John's on February 12, the master stated:

> At 0605 hrs. we resumed pumping Drill Water to PT 13. Shortly thereafter, the Rig listed 2-3 degrees to port-aft. In attempting to correct this situation, tanks P14 and P 2 were opened and ballast pump # 3 was activated. At this point the sea valve was open but not noticed. Ballast pump # 3 could not handle the volume of water to counter-act the sea chest being open. The list increased to 3-4 degrees. I paged the [junior] Control Room Operator who was in the elevator in the lower hold and could not hear the page. We stopped taking Drill Water. The Control Board was shut down. The port-aft list was 5 degrees and [the senior control room operator] was called, who then corrected the situation.

As a result of the report, the MOBIL superintendent requested on February 12 that ODECO analytically determine the list if PT-2 and PT-14 had completely flooded on February 6, 1982. At the time of the accident, ODECO had not performed the analysis.

On January 26, 1982, the ODECO office in St. John's contacted the USCG Marine Inspection Office in Providence and requested inspection of the drilling rig. Arrangements were completed on February 3 for two USCG inspectors to arrive in St. John's on the evening of February 15. After being informed of the accident on the morning of February 15, only one inspector proceeded to St. John's. The ODECO Operations Manager in St. John's testified that he and the OCEAN RANGER's master were responsible for maintaining the currency of the OCEAN RANGER's USCG Certificate of Inspection and that the Certificate of Inspection had expired on December 27, 1981. The Operations Manager stated that the request for inspection had been delayed because ODECO was installing two new lifeboats on the OCEAN RANGER for compliance with USCG requirements and, because of bad weather, the lifeboat installation was running behind schedule. He stated that the lifeboats were being installed in lieu of davit-launched liferafts and that representatives of the lifeboat company had inspected the installation of one lifeboat before the scheduled USCG inspection.

<u>Structure.</u>--The OCEAN RANGER was designed to meet the structural requirements contained in the 1973 ABS "Rules for Classing Offshore Mobile Drilling Units." As a preventive measure to insure against lamellar tearing (a separation within the steel plate), a special modified ABS grade E steel was used at major structural intersections. During December 1979, the Coast Guard completed an extensive inspection of the drilling unit's hull, including all ballast tanks and columns, except for the exterior sides and bottom of the lower hulls which were underwater. On April 4, 1980, an underwater survey of the lower hulls was conducted with both USCG and ABS inspectors present. The USCG inspectors found the hull to be in satisfactory condition with no evidence of damage or corrosion. On June 16, 1981, the ABS conducted an annual survey and loadline inspection. The ABS report stated, in part:

HULL

1. A general examination of the unit's above water vertical columns, diagonals, girders and their interconnections was made as far as practical and all [were] considered satisfactory.

2. The upper platforms deck and associated structures, including areas of possible high stress, were examined and found satisfactory.

3. Coamings and closing arrangements of ventilators to spaces below the freeboard deck [upper deck], hatchway coamings, and hatch covers were examined and found satisfactory.

4. Doors in watertight bulkheads, closing appliances for air vent and sounding pipes, including flame screens where applicable were examined and found satisfactory.

5. All accessible parts particularly liable to rapid deterioration were examined and found satisfactory.

During October 1981, a fully qualified hull and machinery USCG marine inspector with five years' experience in marine inspection, which included drilling rigs, who was on a 1-year industry training tour with ODECO, was requested by the IRR aboard the OCEAN RANGER to perform an informal recertification inspection. The inspector assisted the IRR in preparing a list of safety items to be completed before the required USCG inspection in December 1981. The inspection lasted 4 to 5 days and included every accessible space. The inspector testified that he did not find any structural problems and that "the overall conditions was well above average as far as the housekeeping and maintenance."

On February 4 and 5, 1982, a conservation engineer from the Canadian Department of Energy, Mines and Resources (now Canadian Oil and Gas Lands Administration) inspected the OCEAN RANGER for compliance with certain Canadian regulations. The engineer's report covered drilling equipment and occupational safety. The engineer's only reference to vessel safety was that he noted that an abandon-ship drill had been held on January 31, 1982.

<u>Arrangements.</u>--The upper hull of the OCEAN RANGER was supported by four vertical columns, arranged longitudinally on each side which, in turn, were supported by the port and starboard lower hulls. The columns were subdivided horizontally into watertight compartments. (See figure 2.) The propulsion room and pumprooms were located aft, and the fuel oil, drilling water, and ballast tanks were located forward in each lower hull. Dry mud tanks were contained in the upper portions of the two small center port and starboard columns. The after starboard center column also contained the ballast control room. The deck of the ballast control room was about 28 feet above the waterline at the 80-foot maximum draft. The anchor chain lockers were located in the larger corner columns with their openings about 71.5 feet above the waterline at the 80-foot operating draft. Access to the columns was gained through doors and openings on the lower deck level.

The upper hull consisted of a lower and an upper deck with a raised helicopter deck on the forward starboard corner. Three decks of living accommodations were located below the helicopter deck. The pilothouse was located forward of the accommodations

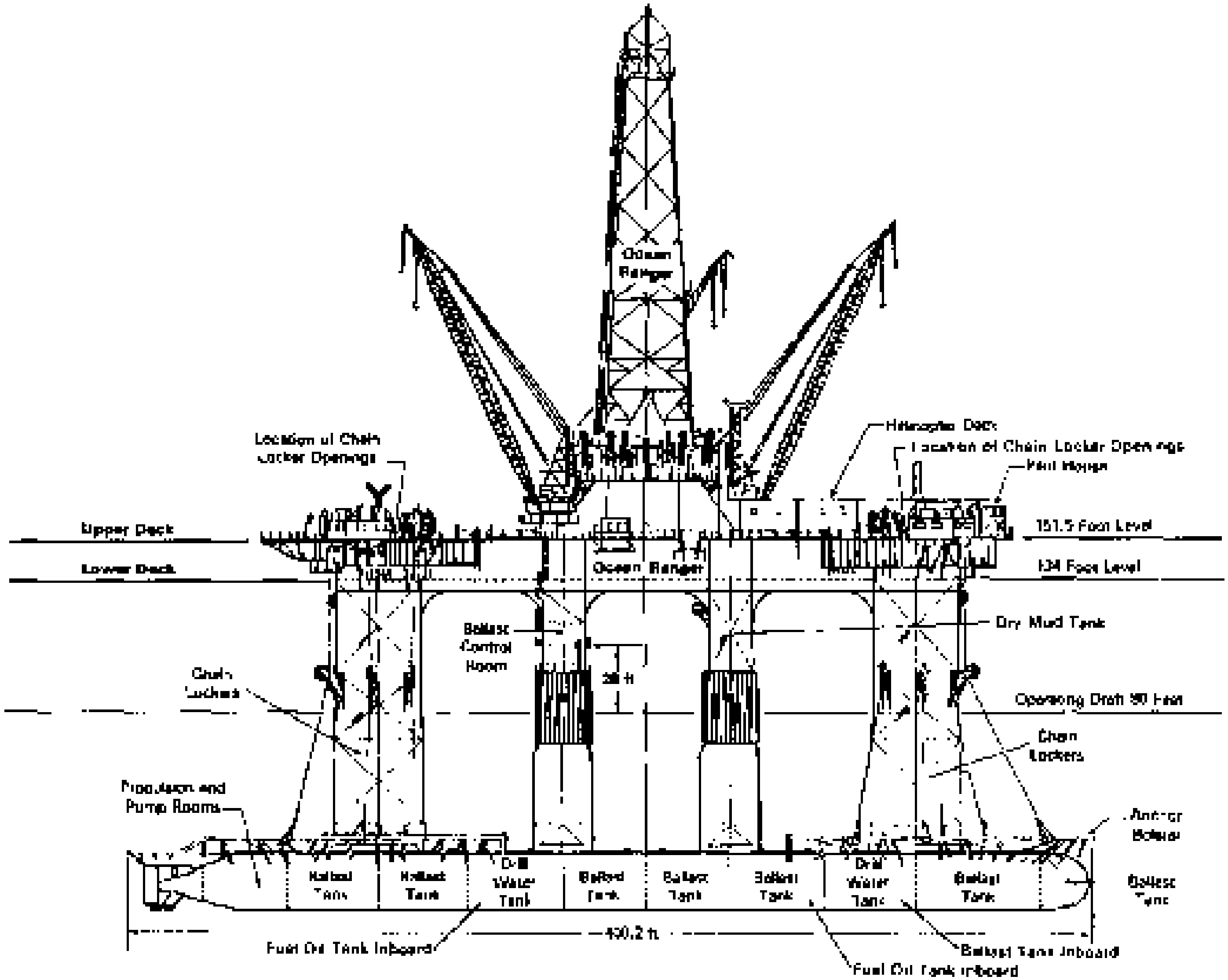


Figure 2.--OCEAN RANGER starboard profile.

on the upper deck. The standby generator room, the drilling unit's service generators room, and various storage areas were located on the lower deck. (See figure 3.)

Two 60-ton capacity and one 50-ton capacity revolving cranes were located on the upper deck. The cranes were located over the two port center columns and the aft starboard center column. The drilling derrick was 213 feet high above the upper deck, which was 71.5 feet above the water at the 80-foot operating draft. Lifeboat stations, the radio room, the MOBIL office, and the ODECO office also were located on the upper deck. (See figures 3 and 4.)

The ballast control room contained the ballast control panel in the forward end of the circular room. One portlight was located on each side of the control panel (see A and B on figure 4); one portlight was located aft of portlight B (see C on figure 4); and one portlight was located in the after end of the control room behind the tank level indicators (see D on figure 4). The portlights were of standard marine design with tempered glass and metal deadlights with securing devices. The port tank level indicators were located on the starboard side of the control room, and the starboard tank level indicators were located on the portside. Two "bubble" type inclinometers were mounted in the control room—one in a fore and aft direction for observing trim, and the other one in an athwartship direction for observing heel. Each inclinometer had two spirit tubes—one with graduations from 0° to 5° and the other one with graduations from 0° to 15°. A similarly mounted pair of inclinometers also were located in the ODECO office. A desk was located in the center of the room with two VHF radiotelephones, sound-powered telephones, and a video display unit with roll, pitch, heave, wind, and wave information. A hydrophone control unit, a carbon dioxide (CO_2) actuating cabinet, a smoke detecting cabinet, and an H_2S gas detecting unit were also located in the center of the room. Access to the control room was gained by a circular ladder within the column from the lower deck of the upper hull. On the outside of the column, a vertical ladder was enclosed in a cage leading down from the upper hull to a walkway that extended two-thirds of the distance around the column at the control room level outside all four portlights. A handrail on the column extended around the outside of the portlights, slightly below their centers.

<u>Radio Communications</u>.--The OCEAN RANGER's radio room was located in the upper deck quarters and was equipped with a main transmitter, a high frequency transmitter, an emergency transmitter, a main receiver, and an emergency receiver. USCG regulations require that a licensed radio officer be aboard when the drilling rig was underway. However, a radio officer was not required while the vessel was moored although two radiotelephone operators were assigned to the vessel to maintain communications with the shore based offices. MOBIL maintained a MARISAT telephone and telex system aboard the OCEAN RANGER in the MOBIL drilling foreman's office for the use of MOBIL's representatives. In addition, MOBIL also had an SSB radio with dedicated frequencies for direct communication to the shore based MOBIL radio station in MOBIL's St. John's office. A second SSB radio was located in the radio room for ODECO's representatives' direct communication with ODECO's office in St. John's. Either SSB radio could be patched into regular telephone landlines as needed. MOBIL also maintained a telex transmitter and receiver in the radio room whereby telex messages could be transmitted directly to MOBIL's office or any other station in the telex network. The daily morning and afternoon reports from the OCEAN RANGER were transmitted in this manner.

A VHF radio was used for communications to and from the supply vessels in the vicinity and the standby boat. The VHF radio was operated from the ballast control room by the master or the control room operator to coordinate loading of fuel oil, drill

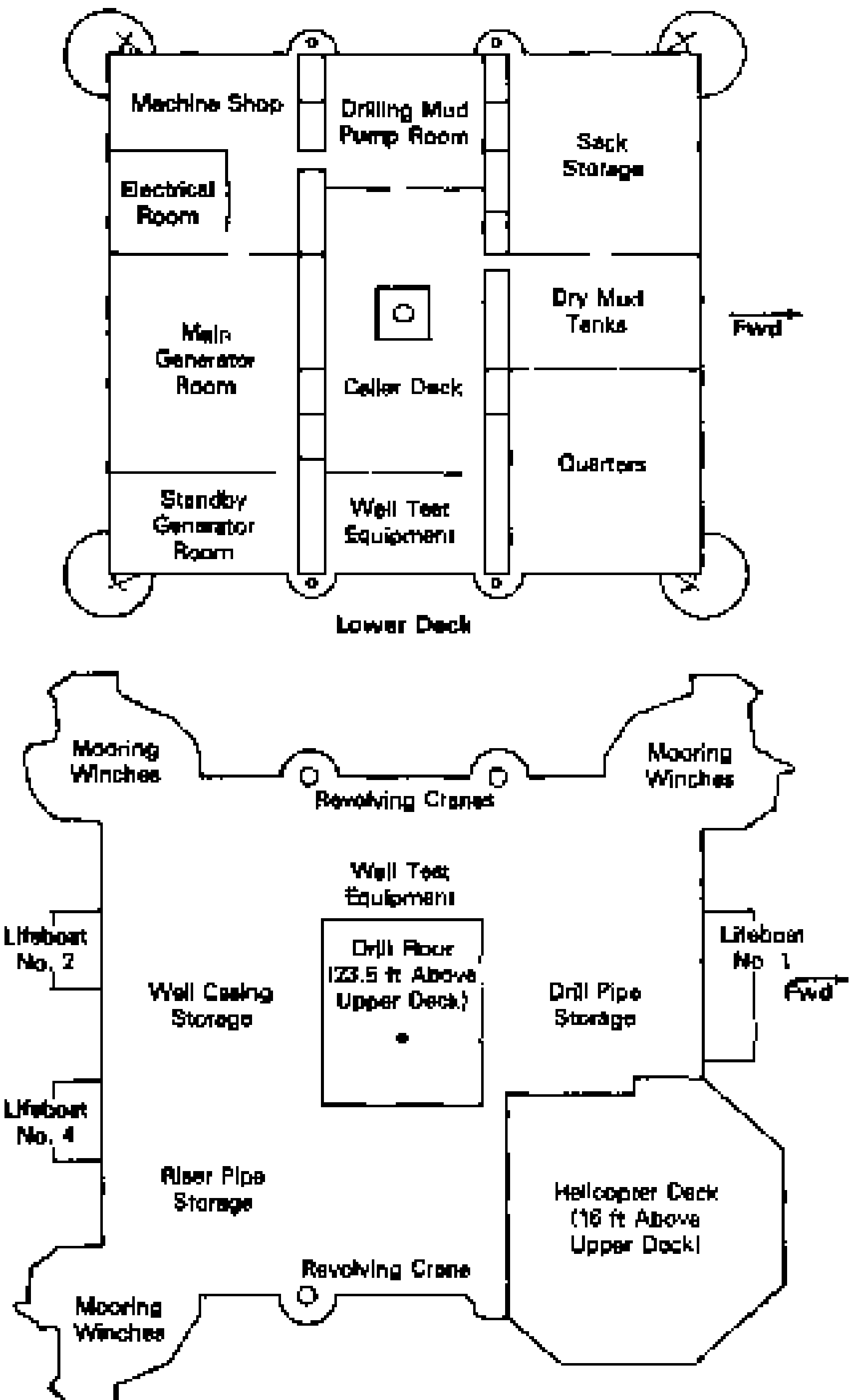
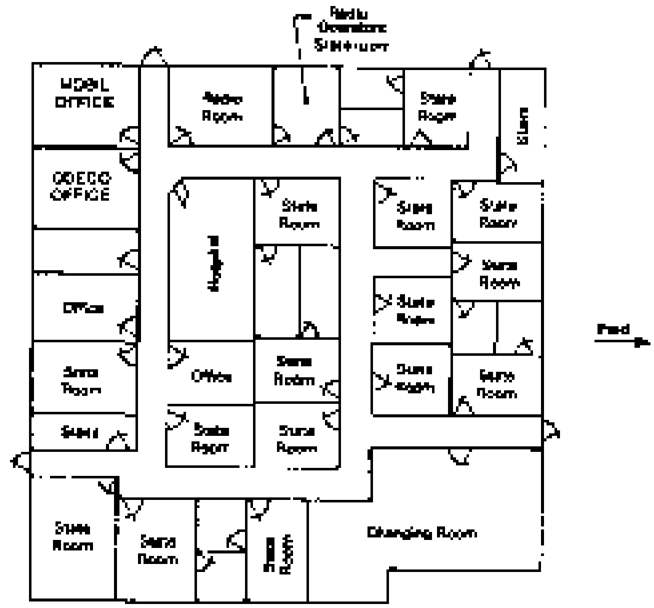
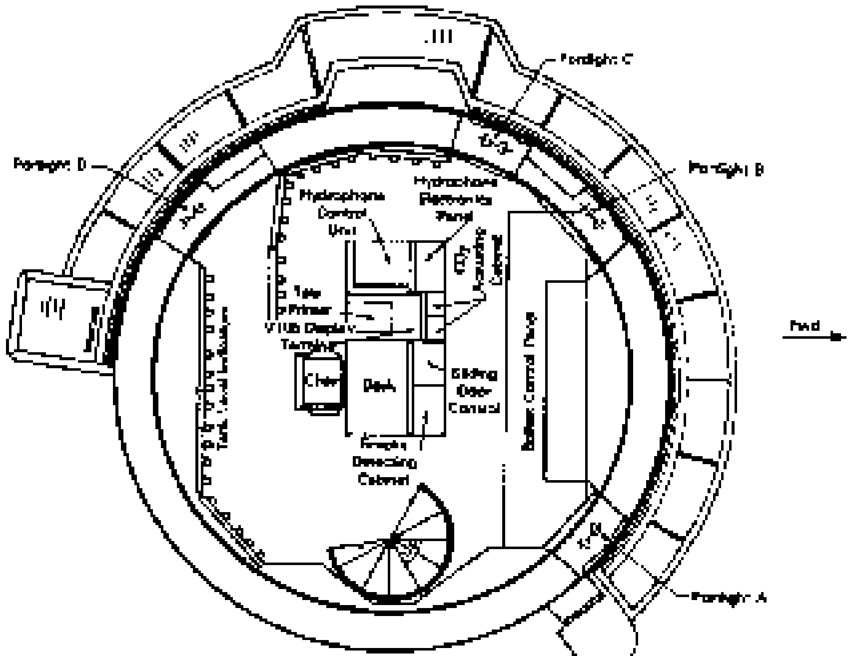


Figure 3.--Lower and upper deck arrangements.



Upper Deck Quarters



Ballast Control Room

Figure 4.--Upper deck quarters and ballast control room arrangements.

water, and stores from the supply vessels. Several portable hand-held VHF radios were used at various times by persons on deck and the crane operators when moving materials to and from supply vessels. The radio room was equipped with a remote speaker to monitor the VHF radio system.

Internal communications were made over a two-way page system in which a person could be called over the system and then reply directly to the caller. Emergency signals and announcements also were made over the system. A sound-powered telephone system connected the navigating bridge, the machinery room, and the propulsion rooms.

A VHF radio with aeronautical frequencies for communication with the helicopters was maintained in the radio room to coordinate the arrival and departure of aircraft. During the night hours when there was no helicopter traffic, the radio operators on the three drilling rigs in the area used this radio for communications between each other.

<u>Ballast System</u>.—The two hulls of the underwater portion of the OCEAN RANGER were symmetrical, but mirror opposite in configuration, and each consisted of 19 separate compartments. (See figure B-1, appendix B.) These compartments were divided into 2 fuel tanks, 2 drill water tanks, 12 ballast water tanks, a pumproom, a propulsion room, and a void space. Each compartment was vented to the atmosphere through vent pipes running up through the eight columns to the underside of the lower deck. The vents then merged into four groups that extended to the upper deck of the structure. Each ballast tank was connected to a common 18-inch manifold in the pumproom by an 8-inch pipeline, which was fitted with a bell mouth near the aft end of the tank to fill and discharge ballast water. A butterfly valve, which was remotely controlled from the ballast control panel, was installed in each ballast line on the tank side of the manifold in the pumproom to control the ballast water. The manifold actually consisted of two manifolds, one over the other, and ran athwartship at the forward end of the pumproom. An 18-inch pipe connected the manifold with three 2,000-gallon-per-minute (GPM) electrically driven multistage ballast pumps and the sea chest. A remote controlled 18-inch butterfly valve, located on the pump side of the manifold, isolated the manifold from the pumps. The branch lines from the 18-inch pipe to the ballast pumps were reduced to 10-inch pipe before passing through a strainer on the suction side of the pumps. A 10-inch remote controlled butterfly valve was located between each strainer and its associated pump. The 18-inch pipe to the sea chest was equipped with two valves to close off the sea chest. The inboard valve was an 18-inch remote controlled butterfly valve while the outboard valve was an 18-inch gate valve that was manually operated in the pumproom. A steel strainer plate was bolted to the exterior of each sea chest. The Nos. 1 and 2 ballast water pumps in both the port and starboard pumprooms were also connected to the drill water port and starboard tanks, respectively, through a 10-inch pipe.

The discharge side of each ballast water pump was connected to a 16-inch discharge line that could be routed either to pump overboard, up to a saltwater tank on the lower deck of the upper hull, or to the 18-inch manifold. It was possible to pump water into the ballast tanks as well as to free flood them by gravity. To keep the saltwater tank on the lower deck filled, a smaller auxiliary pump was installed in the port hull, which reduced the wear on the ballast water pumps.

The ballast system also was capable of pumping the void space, propulsion room, and pumproom of each lower hull through 10-inch emergency bilge suction lines equipped with nonreturn valves. The bilge suction valves were located in each 10-inch line, remotely controlled from the control panel in the ballast control room.

The regular bilge suction system in each hull, also remotely controlled, consisted of two separate pumps and 3-inch piping together with the necessary valves. This configuration allowed pumping of the three spaces in the aft end with either pump separately or any combination thereof.

The two drill water tanks in each hull, although not used as ballast tanks, held almost 800 tons of water each. Each tank was equipped with a 6-inch filling line and an 8-inch suction line, and each could be pumped with the single drill water pump in each hull. These drill water pumps were of lesser capacity than the No. 1 or No. 2 ballast water pumps. If the need arose to dewater those tanks more rapidly, the ballast water pumps could be used. One ODECO engineer testified that the original design of the drill water system required the use of the ballast water pumps; however, the smaller pumps, solely for use in transferring drill water, were installed to save wear and tear on the larger ballast pumps.

The fuel oil storage tanks in each hull had completely separate filling and transfer systems with only manually operated valves for control. To fill or transfer fuel oil, the control room operator was required to go down into the pumproom and set the valves manually to align the system. The only way to rapidly fill the lower hull fuel oil tanks with sea water in an emergency was through the upper deck fuel fill lines.

The ballast control panel in the control room was designed especially for the OCEAN RANGER. A mimic board with the tank configuration and pipeline flow diagram of both the port and starboard hulls showed the operator the relationship of the tanks, piping, and corresponding valve control switches. (See figure 5.) Although the valves to the ballast and drill water tanks actually were located in the pumproom, control switches were mounted in the tank diagram of the mimic board panel. Each side of the panel was equipped with 32 pairs of valve control switches that operated the valves for 16 ballast and drill water tanks, 3 ballast pump suction valves, 1 drill water pump suction valve, 1 ballast pump discharge valve to the saltwater service tank, 1 ballast pump discharge valve to overboard, 1 ballast pump discharge valve to the tank manifold, 3 emergency bilge suction valves, 1 suction and discharge valve to the drill water pump, 1 suction valve to 1 ballast water pump for the drill water system, 1 discharge valve from 1 ballast water pump to the drill water system, 1 stop valve between the tank manifold and the 3 ballast pump suctions, and 1 remote controlled sea chest valve. When depressed, each "open" switch activated a holding relay which, in turn, closed the circuit for the corresponding solenoid valve in the cabinet and opened the circuit for the indicating lamp in the red "close" switch. The solenoid valve admitted compressed air to the tubing connected to the valve operating gear in the pumprooms. The holding relay maintained power to the solenoid valve until the "close" button was depressed on the panel, thereby breaking the circuit at the holding relay, allowing the solenoid valve to return to the closed position, and venting the compressed air to the valve operating gear in the pumproom. The spring-loaded valve operating gear then closed the valve. The air was exhausted inside the control panel, providing the operator with an audible indication of valve closure. The spring-driven method of valve closing provided an automatic safeguard when control air was lost for any reason. If electrical power to the control console was lost, the solenoid valves could be controlled manually by inserting a brass actuating rod into each solenoid. These brass rods were threaded into the end of the solenoid housing through a brass bushing. After contacting the solenoid within the housing, the rods could then be further threaded in to override the solenoid spring. The compressed air would be then admitted to the line connecting the solenoid valve to the valve operating gear in the pumproom. Upon releasing the brass rod, the solenoid would return to its normal position, allowing the air to escape and the valve to close.

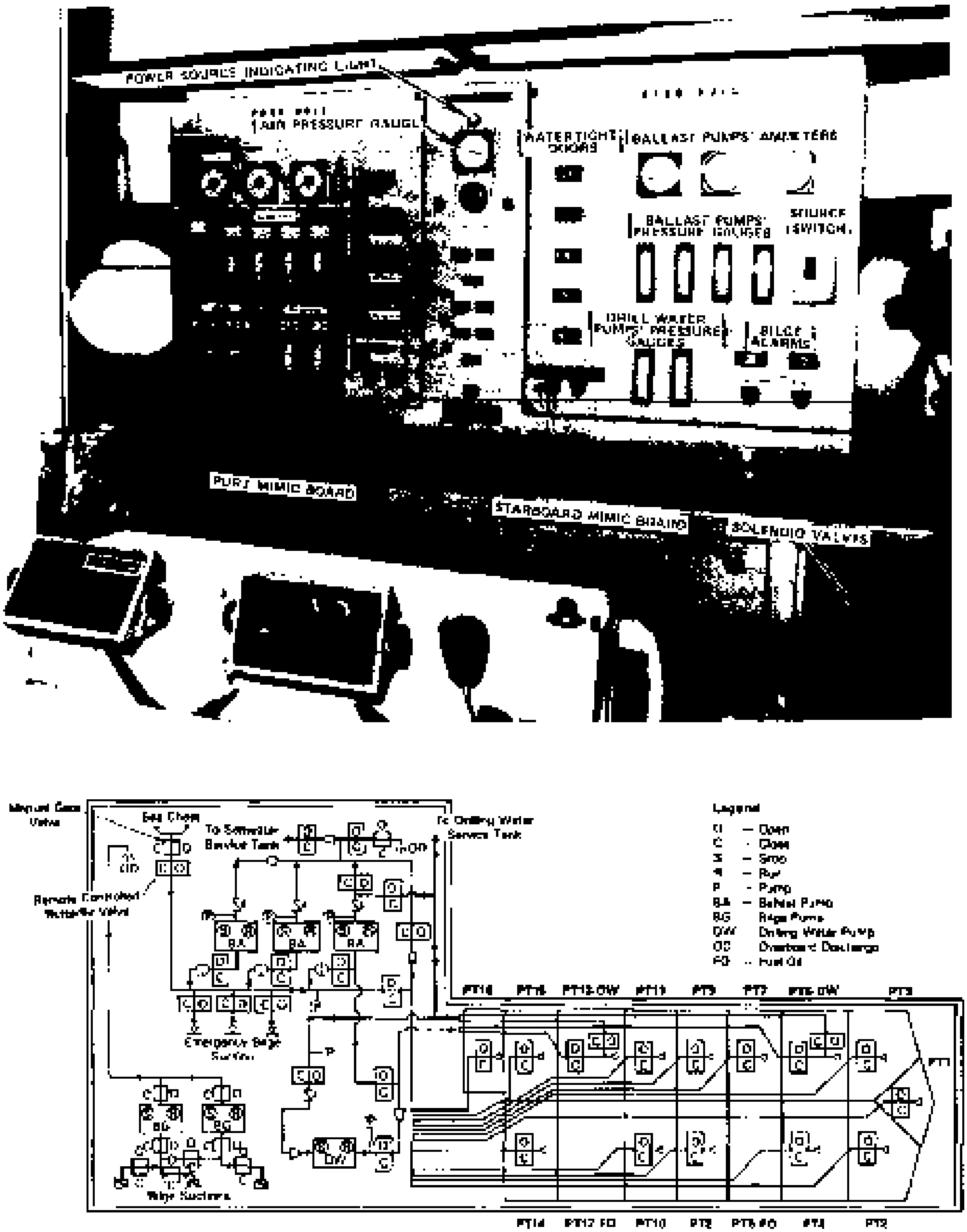


Figure 5.—Ballast control console and details of port mimic board.

The control panel switches also provided visual indication of the position of each valve through an electrical circuit activated by a microswitch at the valve operating gear in the pumprooms. The switch buttons on the panel were color coded. A valve in the closed position showed a red light on the "close" side of the switch, and a valve in the open position showed a green light on the "open" side of the switch. If the valve was in motion, either during closing or opening, or stopped in mid-position for any reason, both lights would go out. There was no provision for throttling. The valves were designed to be either fully opened or fully closed. The manual valve at the sea suction also was equipped with an indicator on the control panel.

The three ballast water pumps, the drill water pump, and the two bilge pumps normally were controlled from the control panel. The position of each switch in the system was indicated with lighted buttons on the flow diagram on the panel. A red light indicated a stopped pump and a green light indicated an operating pump. These switches remotely activated the motor controllers in the pumprooms which, in turn, closed the circuit to start the pump motors.

The vertical portion of the control panel, which was separated port and starboard, contained the pressure gauges for the ballast water pumps and the drill water pumps. The watertight door and hatch controls and alarms were grouped together and indicated the status of each watertight door and hatch in the columns and the propulsion and pumprooms. There were six ammeters, one for each of the ballast pumps, which gave indications of the electrical load on each pump during operation. The bilge level alarm indicators, with an auto/manual select switch for each pumproom and propulsion room, provided an indication in the control room when water reached a predetermined level in these spaces.

The high- and low-level alarms for the drill water tank, the sea water tank, and the three fuel oil tanks in the upper hull were located in the center of the vertical panel. A power source indicating light and a control air pressure gauge provided the information on the primary sources of control.

A senior control room operator, who had served aboard the OCEAN RANGER between June 1976 and December 1981, testified that he did not know of any manual method of controlling the lower hull valves from the control room but that electrical power to the valve controls could be shut off by a circuit breaker inside the vertical panels on the control console. A master, who had served aboard the OCEAN RANGER between September 1978 and January 29, 1982, testified that the source switches on the outside of the vertical panels shut off electrical power to the valve control switches and that the valves could be operated manually in the control room by inserting rods into the solenoid valves. However, there was no evidence that anyone aboard the OCEAN RANGER on February 15 had ever used the actuating rods or that there were any operating instructions for their use aboard the OCEAN RANGER. The off-duty electrician testified that the source switches on the vertical panels shut off all electrical power to the control valves, and an ODECO electrical engineer testified that each source switch controlled only the power supply to the ballast and drill water pump electric pressure indicators on each vertical panel.

The OCEAN RANGER's draft was read directly from draft gauges which had been mounted on the four corner columns and easily visible from the portholes of the ballast control room. At night, the control room operator was provided a portable searchlight to illuminate the gauges. There were no internal draft gauges.

Survival Systems.--The OCEAN RANGER was equipped with two Harding 50-person Norwegian authority-approved fibrous glass reinforced plastic covered lifeboats (Nos. 1 and 2) installed in davits. The No. 1 lifeboat was located on the portside of the forward end, and the No. 2 lifeboat was located on the portside of the aft end. Neither lifeboat met USCG standards because neither could be released until it was completely waterborne and there was no load on the falls. The drilling unit also was equipped with two Watercraft 58-person USCG-approved fibrous glass reinforced plastic covered lifeboats (Nos. 3 and 4). The No. 4 lifeboat was operational and installed in davits on the starboard side of the aft end, but the No. 3 lifeboat was lashed to the upper deck with no provisions or equipment. Both types were self-righting if all persons on board were seated and secured to their seats by seatbelts and there was no significant accumulation of water inside the boat. The OCEAN RANGER also was equipped with ten 20-person USCG-approved inflatable liferafts located on the forward and after ends of the drilling unit near the lifeboats, 127 USCG-approved adult life preservers with lights and retroreflective material, 25 USCG-approved buoyant work vests, 15 ring buoys with lines and lights, and an emergency position indicating radio beacon (EPIRB). No exposure suits 11/ were aboard the OCEAN RANGER; however, a few survival suits 11/ were provided personnel for wearing when riding in helicopters to and from the drilling unit. As required by Canadian regulations, a standby boat was assigned to the OCEAN RANGER at all times.

Both ODECO and MOBIL had developed emergency procedure manuals for persons responsible for the safety of the OCEAN RANGER. The ODECO manual, which included sections on fire, blowouts, icebergs, collisions, and severe storm conditions, stated that the safety engineer (IRR) was responsible for familiarizing all personnel and visitors with safety equipment and that the toolpusher had overall responsibility for all personnel and drilling unit safety. The MOBIL manual had similar sections on fire, blowouts, icebergs, collisions, and severe storm conditions; however, its section on severe storms did not contain any procedures for evacuation of personnel, mobilization of equipment, or notifying appropriate individuals. The MOBIL manual only stated that the toolpusher or MOBIL drilling foreman should call the MOBIL drilling superintendent at the first opportunity and that the drilling superintendent should "consult with necessary staff together with Rig Manager [toolpusher] to decide appropriate plan of action and possible rig evacuation."

Waterway Information

At the time of the accident, the OCEAN RANGER was engaged in exploratory drilling on the Grand Banks of Newfoundland in an offshore oil field, referred to as the Hibernia Discovery, located about 166 nmi east of St. John's, Newfoundland, in depths of up to 295 feet of water. The oil field contains about 1.9 billion barrels of recoverable oil, 1.5 trillion cubic feet of recoverable solution gas, and 0.5 trillion cubic feet of recoverable nonassociated gas. 12/ Formidable engineering challenges in the development of this oil field are present because of the seasonable pack-ice and icebergs and the cold ocean environment of the North Atlantic. During the morning of February 15, 1982, the recorded sea temperature and air temperature were 31° F and 24° F, respectively. Ocean currents in the Grand Banks are generally from the north-northwest, flowing from the Labrador sea at a velocity of about 0.5 knot.

11/ Exposure suits provide thermal protection for several hours against cold water exposure while survival suits provide only limited thermal protection.
12/ Proceedings of the Symposium for the Hibernia Discovery, Petroleum Directorate of Newfoundland and Labrador, 1981.

The Grand Banks is one of the most productive fishing grounds in the North Atlantic. The junction of the warmer waters of the Gulf Stream and the cold water of the Labrador current produces almost continuous periods of fog throughout the area in the spring and rain or snow throughout the rest of the year. Coupled with high winds and seas, the environment poses a continuous threat to the men and equipment engaged in drilling, fishing, and the support of these important industries.

Meteorological Information

At 2030 on February 13, 1982, average wind speeds observed on the OCEAN RANGER increased from 4 knots to a maximum of 72 knots reported at 1630, 1730, and 2030 on February 14. The wind direction shifted from 220° at 1730 on February 14 to 270° at 2330 on February 14, at which time the wind speed was 58 knots.

On the drilling rig SEDCO 706, average wind speeds decreased from 68 knots at 0000 on February 15 to 55 knots at 0400. The wind direction veered from 250° at 0000 to 260° at 0400. A maximum wind gust of 88 knots from 220° was observed on the OCEAN RANGER at 1630 on February 14. On February 15, maximum wind gusts of 75 knots were observed on the SEDCO 706 at 0000 and again at 0200. The wind direction at 0000 was 250° while it was 260° at 0200.

Significant wind wave heights observed by personnel on the OCEAN RANGER increased from about 5 feet at 0230 on February 14 to about 33 feet at 2030 and 2330 on February 14. The height of the sea swell was reported about 7 feet at 0230 on February 14 and increased to 23 feet at 2330 on February 14. The last marine observation report from the OCEAN RANGER indicated a significant wind wave height of about 33 feet from 270° with a period of 11 seconds, and a sea swell height of 23 feet from 230° with a period of 9 seconds. This observation was made at 2330 on February 14.

On the SEDCO 706, the average sea height was observed at 30 feet at 0000 on February 15 with a maximum sea height of 50 feet. Average sea heights increased to 34 feet at 0300 on February 15 and then decreased to 27 feet the next hour. Maximum sea heights increased to 59 feet at 0300 and decreased to 49 feet at 0400.

Storm warnings were in effect at the time and for the area of the accident. The marine forecast issued by Environment Canada 13/ at 2000 on February 14 predicted northwest gales of 50 to 70 knots. A forecast issued by NORDCO, Ltd., at 1930 on February 14, predicted winds from 270° at 75 knots gusting to 90 knots with significant sea wave height of 25 feet, maximum wave height of 44 feet, and a wave period of 9 seconds at 2030 on February 14 and winds from 330° at 70 knots gusting to 80 knots with a significant sea wave height of 33 feet, maximum wave height of 59 feet and a period of 10 seconds at 0230 on February 15. The marine forecast issued by the U.S. National Weather Service Forecast Office in Washington, D.C., at 1830 on February 14 and at 0030 on February 15 predicted winds of 50 to 80 knots and seas of 20 to 35 feet for the approximate time and area of the accident.

Wind observations aboard the OCEAN RANGER, SEDCO 706, and ZAPATA UGLAND were made by weather observers certified by the Canadian Weather Service. According to an official of the Canadian Weather Service, winds reported in the weather observations from the OCEAN RANGER, SEDCO 706, and the ZAPATA UGLAND were obtained from a wind sensor located on top of the derricks.

13/ The Canadian counterpart of the U.S. National Weather Service.

Wave determinations aboard the OCEAN RANGER and SEDCO 706 were made visually while significant wave heights, peak wave periods, and maximum wave heights for the ZAPATA UGLAND were obtained from a waverider accelerometer buoy located near the drilling unit.

Wreckage

From February 18 to March 2, 1982, a side scan sonar survey was conducted of the wreckage of the OCEAN RANGER. The survey showed the drilling unit resting on the bottom in an inverted position about 500 feet southeast of the wellhead and drill pipe and other debris scattered 900 feet from the sunken drilling unit in a northwest to southeast direction. (See figure 6.) The derrick is located about 200 feet northwest of the OCEAN RANGER. The survey indicated that anchor cables in the fore and aft direction had parted while at least one transverse anchor cable to each corner column remained intact. A videotape survey conducted in early March 1982 did not indicate any structural damage to the hull, except minor damage to the bows of both lower hulls and two broken portlights in the control room. The portlight behind the tank gauges (portlight D, figure 4) and the next portlight near the portside of the control console (portlight C, figure 4) were broken. The deadlights on all control room portlights were found closed.

As a result of the Canadian Coast Guard's search and rescue efforts, the No. 1 and the No. 3 lifeboats, parts of the No. 2 lifeboat, 4 liferafts, 21 Billy Pugh Model 200 life preservers, 1 work vest, and the OCEAN RANGER's EPIRB were recovered. However, the No. 4 lifeboat has not been recovered. The bow of the No. 1 lifeboat was ripped open. An analysis by a USCG lifeboat expert of the port and starboard L-shaped marks near the bow of the No. 1 lifeboat, which match the stabilizer chocks of the boat's davits, determined that the launching sequence for the No. 1 lifeboat had not begun or had just begun when it tore from the launching platform. Over 40 of the No. 1 lifeboat's seatbelts did not have the male end attached. Some were fastened to the female end while others laid in the bilges. The canopy and hull of the No. 1 lifeboat was damaged during the recovery operation. Only a transverse thwart provision locker, the propeller and shaft, and two pieces of flotation foam were recovered from the No. 2 lifeboat. The propeller and shaft were pulled out during recovery operations. The No. 3 lifeboat had been lashed on the upper deck of the OCEAN RANGER and had no provisions. During recovery operations, its canopy was torn off and the hull broke into two pieces one-third of the way aft of the bow.

After four of the recovered liferafts were brought ashore in St. John's, they were examined by a Safety Board investigator. The floor of liferaft No. 710 had separated from the lower buoyancy chambers for about 80 percent of the liferaft's perimeter. Liferaft No. 712 was recovered fully inflated. Liferaft No. 715's upper buoyancy chamber was separated from its lower chamber for about 75 percent of its perimeter. The upper buoyancy chamber and canopy with its identifying number were missing from the fourth liferaft.

Medical and Pathological Information

Records from the Registrar, Vital Statistics Division, Department of Health, St. John's, Newfoundland, indicate that all 22 persons whose bodies were recovered died of hypothermia -- loss of body heat to the water. The remaining persons on board the drilling rig at the time of the accident are missing and are presumed dead. The following chart extracted from USCG regulations (33 CFR181.705) shows the effects of hypothermia:

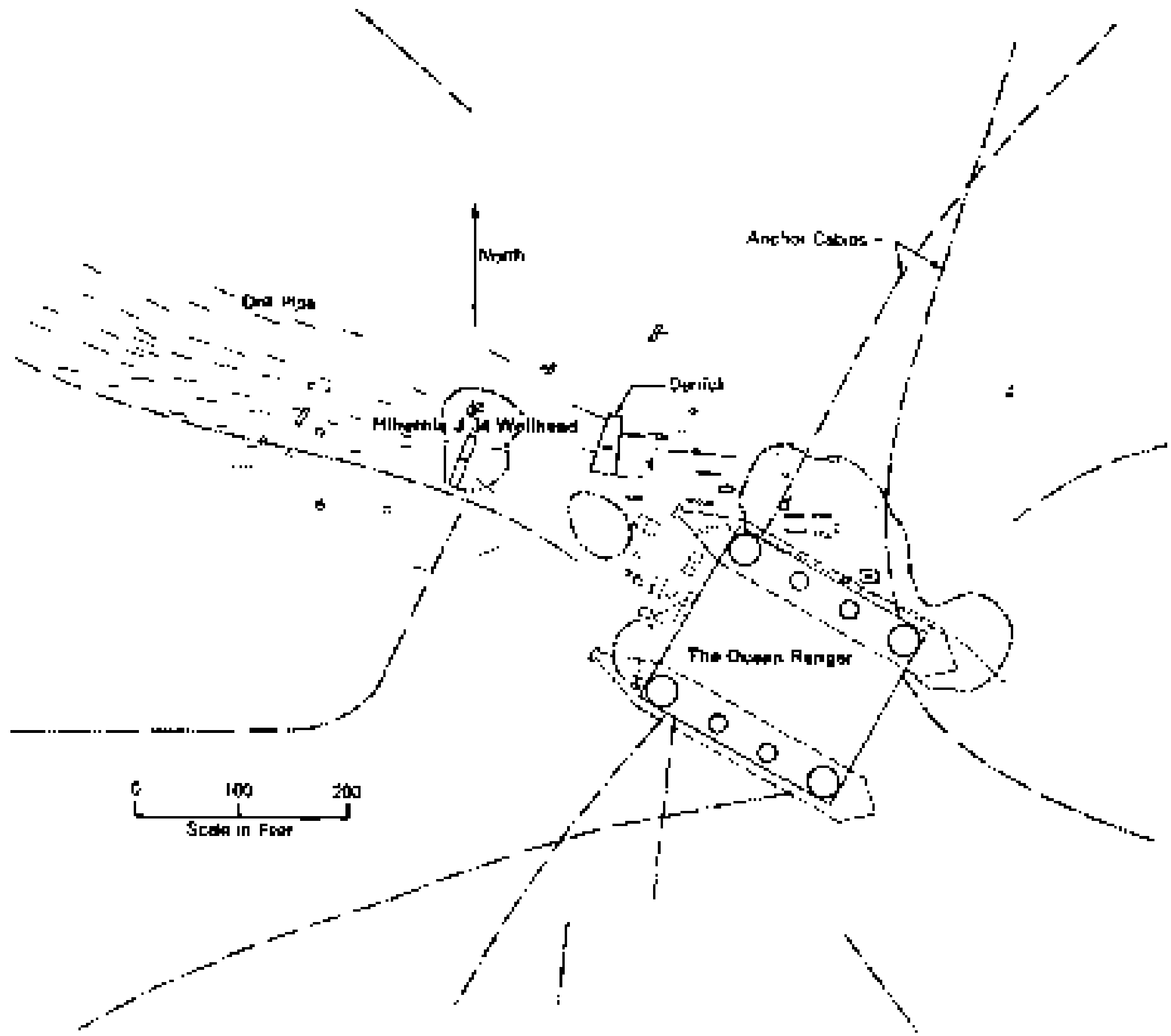


Figure 6.--March 8, 1982, side scan sonar survey of the OCEAN RANGER.

Water Temperature	Exhaustion or Unconsciousness	Expected Time of Survival
(° F)	(Time)	(Time)
32.5	Under 15 min.	Under 15 to 45 min.
32.5 to 40	15 to 30 min.	30 to 90 min.
40 to 50	30 to 60 min.	1 to 3 h
50 to 60	1 to 2 h	1 to 6 h
60 to 70	2 to 7 h	2 to 40 h
70 to 80	3 to 12 h	3 h to Indefinite
Over 80	Indefinite	Indefinite

Survival Aspects

The first distress message sent from the OCEAN RANGER was received by the radiotelephone operator on duty on the SEDCO 706 at 0052. About 0100, the MOBIL senior drilling foreman on the OCEAN RANGER called the MOBIL superintendent at his home in St. John's and requested him to alert the Canadian Coast Guard (CCG) because they were experiencing a severe listing problem. At 0107, the MOBIL superintendent telephoned the CCG in St. John's and alerted them to the OCEAN RANGER's problem and that the winds were in the 80-knot range and the maximum combined seas were in the 50-foot range. At 0110, the MOBIL superintendent telephoned the MOBIL transportation supervisor in St. John's and instructed him to have the MOBIL contracted helicopters in St. John's prepared to go to the OCEAN RANGER. At 0115, the MOBIL superintendent advised the CCG in St. John's that there were three standby boats in the area and that the MOBIL contracted helicopters were being readied. At 0122, CCG St. John's notified RCC Halifax, which coordinated all search and rescue efforts.

The first boat to arrive at the accident site was the SEAFORTH HIGHLANDER. About 0150, the master of the SEAFORTH HIGHLANDER sighted the OCEAN RANGER about 0.2 nmi upwind from his position. At the same time, he saw flares and proceeded in their direction. The master testified that he saw the lights from at least 20 lifejackets in the water and that he saw a lifeboat with a large hole in the bow and someone bailing water as it approached his vessel.

The chief officer of the SEAFORTH HIGHLANDER, who was on the after deck at the time, testified that, as the lifeboat approached, he saw one man standing at the control position on the after end of the lifeboat, other people bailing water out of the lifeboat through open starboard hatches, and that the bow of the lifeboat had been smashed and holed. After a line from the SEAFORTH HIGHLANDER was attached to the lifeboat, the chief officer saw five or six people climb out of the port hatches and stand on the edge of the lifeboat, and then the lifeboat slowly capsize. Later, he saw people wearing lifejackets floating face down in the water. He said that the crewmembers of the SEAFORTH HIGHLANDER were wearing foul weather gear but that they did not have exposure suits designed for rescue operations and that their rescue equipment consisted of one grappling hook and heaving lines.

About 0245, the second vessel, the BOLTENTOR, arrived on the scene. At the time, the OCEAN RANGER was dark except for two or three small lights. The BOLTENTOR remained near the rig for about 5 to 10 minutes and then proceeded to assist the SEAFORTH HIGHLANDER in rescuing survivors in the water. About 0315 to 0330, the BOLTENTOR cautiously approached the SEAFORTH HIGHLANDER, which was about a mile to a mile and a half from the OCEAN RANGER. Crewmembers aboard the BOLTENTOR saw about 20 to 30 small lights, which they identified as being attached to lifejackets bobbing around in the water. Upon closer examination, using a searchlight, they saw bodies suspended in the straps of the lifejackets.

About 0400, the NORDERTOR joined the SEAFORTH HIGHLANDER and the BOLTENTOR in the search for survivors. The BOLTENTOR's crew remained on deck with liferings and boathooks to retrieve any survivors, but the severity of the wind and sea conditions prevented the boat from maneuvering alongside the bodies. After repeated attempts to retrieve the bodies were not successful and after several of the crewmembers were violently thrown about the deck by the boarding seas, at 0600, the BOLTENTOR's master suspended rescue operations.

Meanwhile, at 0131, the rescue unit in Gander, Newfoundland, had been alerted to the OCEAN RANGER's distress message by the Canadian Coast Guard RCC in Halifax, Nova Scotia. Because of weather conditions at Gander and St. John's, helicopters were delayed in leaving Gander for St. John's until 0358. The MOBIL helicopters at St. John's were prepared for possible evacuation of the OCEAN RANGER. However, when the MOBIL office at St. John's learned that a lifeboat had been launched from the OCEAN RANGER, Canadian Forces Search and Rescue (SAR) helicopters were requested since the MOBIL helicopters were not equipped with hoisting apparatus. About 0330, two MOBIL helicopters departed St. John's and arrived at the accident site about 0430.

At 0358, a Canadian Forces SAR helicopter departed Gander and proceeded to St. John's for refueling before departing for the accident site. At 0456, MOBIL's St. John's office reported to Halifax RCC that its helicopters had been unable to locate the OCEAN RANGER but that the helicopters had spotted lights in the water. A Canadian Forces SAR fixed wing aircraft departed Greenwood, Nova Scotia, at 0714 and, after flying about 685 nmi, arrived at the accident site at 1120. Two Canadian Forces SAR helicopters departed St. John's at 0821 and arrived at the scene about 0935. The pilots stated that they saw numerous bodies and lifejackets floating in the water and bodies hanging suspended in the straps of the lifejackets. No attempt was made to recover the bodies at the time because of the wind and sea conditions. The pilots also sighted two damaged lifeboats but saw no signs of life.

The MOBIL helicopter pilots stated that, in the dark, the small lights attached to the lifejackets were easily spotted but as daylight approached, the small lights became difficult to see. In full daylight, with the sea conditions that existed on the morning of February 15th, it was almost impossible to sight the lifejackets. The master of the BOLTENTOR said that the fluorescent tape that was attached to the lifejackets was highly visible when illuminated by their searchlight.

Shortly after 0500, MOBIL's St. John's office dispatched the offshore supply vessels KRUSENTURM and RAVENSTURM to the scene to aid in the rescue operations.

By 1900 on February 15, seven helicopters, one fixed wing aircraft, and four boats at the accident site had searched for survivors from the OCEAN RANGER. The combined efforts of both aircraft and surface vessels located lifeboats, liferafts, and floating bodies; however, no crewmembers of the OCEAN RANGER were found alive. The NORDERTOR recovered one body, which was later brought to St. John's and turned over to the Royal Canadian Mounted Police.

On February 16, additional ships and aircraft were mobilized. The MOBIL drilling foreman aboard the SEDCO 706 was in charge of the supply vessels; RCC Halifax was in overall command of the operation; and the on scene commander was aboard the Canadian Forces fixed wing aircraft. At 0586, a drift plot was received by RCC Halifax from the USCG RCC in New York. The drift plot provided the farthest positions at that time of the drift of a person, a liferaft, and a lifeboat in the given weather conditions. The surface vessels were assigned search areas accordingly which were coordinated with the aircraft search areas. Two additional supply vessels, the SCHNOORTURM, and the NEUTOR, were assigned as standby boats to the SEDCO 706 and the ZAPATA UGLAND, respectively. The NEUTOR provided aviation fuel to the SEDCO 706 to replenish the fuel supply for the helicopters in the area.

At 1115, the JAVA SEAL, a seismic exploration vessel, reported that it was standing by an overturned lifeboat in position latitude 46°N.00°, longitude 48°14' W., about 38 nmi southeast of the OCEAN RANGER's position, awaiting the arrival of the NORDERTOR. At 1220, the NORDERTOR picked up the lifeboat and at 1314 returned to St. John's.

Several helicopters made numerous sightings of lifeboats and debris, including half a lifeboat. Surface vessels in the area were dispatched to investigate for signs of life; however, no persons were found alive. The supply boat SCHNOORTURM picked up one body later on in the day. At 1405, the BOLTENTOR picked up a second lifeboat about 41 nmi southeast of the accident site. Canadian Forces flew a total of 9.3 hours searching an area of about 500 square miles.

On February 17, the Canadian Coast Guard vessel BARTLETT arrived 14 miles south southwest of the OCEAN RANGER's site. It was directed by RCC Halifax to position the surface vessels for a more effective search pattern. At 0700, the JAVA SEAL recovered a liferaft containing two bodies about 25 miles south southeast of the accident site. It also recovered 10 bodies floating in the same general vicinity. The Canadian survey vessel HUDSON recovered five bodies in the same area. The supply vessels BOLTENTOR and RAVENSTURM each recovered liferafts about 80 miles southeast of the OCEAN RANGER's site. A USCG fixed wing Hercules aircraft, which had departed Elizabeth City, North Carolina, at 1301 on February 16, arrived in the area about noon. Three Canadian Forces helicopters flew a total of 7.4 hours in the search area, and the Canadian Forces fixed wing aircraft flew a total of 10.3 hours.

On February 18, 1982, the search area was expanded to 120 nmi southeast of the OCEAN RANGER's position. The USCG aircraft sighted a liferaft which was later recovered by the SEAFORTH HIGHLANDER. The JAVA SEAL recovered one body in the same general area of the recoveries made on the previous day. About 1530, search vessels with bodies aboard were ordered by RCC Halifax to return to St. John's after MOBIL's office in St. John's requested their return.

On February 19, 1982, both the Canadian Forces and MOBIL reduced their search efforts. The USCG aircraft was released and returned to its U.S. base. Numerous EPIRB reports were received from high flying aircraft early in the morning and resulted in the BOLTENTOR recovering additional rafts and some debris, but no survivors.

At 0640, on February 20, the BARTLETT sighted two liferafts and a body; one liferaft and the body were recovered, but the second liferaft sank. The BOLTENTOR arrived at the site of the reported debris and recovered a body, but it did not recover the EPIRB. At 1426, the Canadian Coast Guard vessel BARTLETT recovered the EPIRB about 87 nmi south southeast of the accident site. The markings on the instrument read "OCEAN RANGER (KRTB)."

The SAR activities between February 21, 1982, and March 1, 1982, resulted in no significant events other than landing the recovered bodies, debris, and wreckage at St. John's. The lifeboat that had the bodies still strapped in the seats and which the NORDERTOR had been unsuccessful in recovering has never been found. On April 28, 1982, the Defense Mapping Agency Hydrographic/Topographic Center (USA) broadcast and published a notice to mariners for vessels to report to the USCG any sightings of the capsized lifeboat from the OCEAN RANGER.

Tests and Research

Stability.--The USCG Merchant Marine Technical Branch in New Orleans performed stability calculations 14/ to determine the effects of wind, mooring system, draft, ballast transfers, and flooding on the stability of the OCEAN RANGER in calm water. The loading condition was based on the OCEAN RANGER's weekly stability report of February 9 and its daily morning reports 15/ from February 9 to February 14. A vertical center of gravity of 63 feet above the keel was used in the calculations. (Figure B-1, appendix B, shows the arrangement of the tanks in the lower hull. Table I shows the assumed liquid loading of the OCEAN RANGER's lower hulls on February 15.)

Table I.--Liquid loading of the OCEAN RANGER's lower hulls on February 15.

Tank	Percent Full	Long Tons	Tank	Percent Full	Long Tons
PT-1	1	5	ST-1	1	5
PT-2	72	691	ST-2	100	960
PT-3	100	960	ST-3	100	960
PT-4	5	37	ST-4	61	498
PT-5	10	80	ST-5	12	96
PT-6	16	107	ST-6	4	27
PT-7	2	12	ST-7	2	12
PT-8	100	711	ST-8	100	711
PT-9	100	711	ST-9	100	711
PT-10	100	711	ST-10	100	711
PT-11	100	711	ST-11	100	711
PT-12	26	174	ST-12	17	113
PT-13	47	276	ST-13	30	176
PT-14	88	719	ST-14	87	710
PT-15	100	818	ST-15	100	818
PT-16	100	347	ST-16	100	347
Total		7,070	Total		7,568

The results were as follows:

- o In all cases with the OCEAN RANGER moored on a heading of 311° on February 15, it would have rotated about a horizontal axis 45° on the starboard bow and it would have experienced a starboard quarter list -- opposite to its reported port bow list -- with the wind blowing from the west.

14/ "Report on the Stability of the MODU OCEAN RANGER," May 27, 1982.

15/ The morning reports were telexed every morning to the ODECO office in St. John's and contained information on weather, stability, equipment, consumable liquids, and drilling operations.

- o Given a 100-knot wind, no initial heel or trim, and an ineffective mooring system, the maximum angle calculated was about 17.5°.
- o Given a 100-knot wind, no initial heel or trim, and an effective mooring system, the maximum angle calculated was about 14°.
- o Given a 100-knot wind, no initial heel or trim, and a draft which decreased from its operating draft of 80 to 68 feet, the maximum list angle decreased from about 17.5° to about 14°.
- o Given a 70-knot wind, no initial heel or trim, and an 80-foot draft, the maximum list decreased to about 15.5°.
- o Given a 70 knot wind, an 80-foot draft, and an effective mooring system, the starboard quarter list would have been reduced to about 4°.

Two hypothetical ballast transfer scenarios with the OCEAN RANGER operating at an 80-foot draft were studied. In the first scenario, ballast water was transferred from the after-most to the forward-most tanks. Transferring the ballast water forward in the lower port hull and assuming that the mooring system was effective resulted in a port bow list of about 23°; flooding of the port bow chain locker would occur at a list of 24°. In the second scenario, when ballast water was transferred from the four port center tanks (Nos. 8 through 11) to empty or partially empty forward ballast tanks (Nos. 1, 2, 4, and 7), and assuming that the mooring system was effective, the resulting port bow list was about 15°.

Flooding the empty or partially empty ballast tanks in the port hull and assuming the mooring system was effective resulted in a mean draft of 94 feet and a list of about 21°. At a draft of 94 feet, flooding of the port bow chain locker would occur at 18°. Assuming the mooring system was not effective, increased the resulting lists 2° to 4°.

Because of the reported port bow list, the effect of flooding the port bow chain locker was also studied. Assuming that the OCEAN RANGER was operating at an 80-foot draft, that there was no trim or list, and that the mooring system was effective, the resultant port bow list for various levels of flooding water in the port bow chain locker would have been as follows:

Flooding (feet)	Weight (long tons)	List Angle (degrees)
5	154	2.5
10	308	6.5
15	462	10.0
20	615	13.5
25	769	15.5
30	923	16.5
35 (full)	1077	17.5

<u>Seakeeping</u>.--The U.S. Coast Guard Marine Technical and Hazardous Materials Division in Washington, D.C., performed seakeeping calculations 16/ to determine at what list angle and mean draft flooding would have occurred in the OCEAN RANGER's port

16/ "An Evaluation of the Effect of the Seaway on the MODU OCEAN RANGER in a Severe Storm," August 1982.

bow chain locker. The calculations considered only static conditions. The effects of heave, roll, and pitch were not included. As noted, the May 27, 1982, stability study indicated that, if the port bow chain locker had been filled with water, the OCEAN RANGER would have experienced a list of about 17.5°, assuming that the mooring system had been effective. The results of the seakeeping calculations indicated that:

1. At a mean draft of 80 feet and no list under the sea conditions that existed on February 14 and 15, 1982, flooding in the port bow chain locker would not have occurred.

2. At a mean draft of 80 feet and about a 14.5° port bow list, flooding in the port bow chain locker would have occurred.

3. At a mean draft of 85 feet and about a 13° port bow list, flooding would have occurred.

4. At a mean draft of 90 feet and about a 12.5° port bow list, flooding would have occurred.

5. At a mean draft of 95 feet and a 10.5° port bow list, flooding would have occurred.

The U.S. Navy David Taylor Naval Ship Research and Development Center, performed similar seakeeping calculations. 17/ The effects of heave, roll, and pitch were included in the calulations. The results of these calculations indicated that:

1. At a mean draft of 80 feet and no list and under the sea conditions that existed on February 14 and 15, 1982, flooding of the port bow chain locker would not have occurred.

2. At a mean draft of 80 feet and about a 24° port bow list, flooding of the port bow chain locker would have occurred.

3. At a mean draft of 85 feet and about a 22° port bow list, flooding of the port bow chain locker would have occurred.

4. At a mean draft of 90 feet and about a 20° port bow list, flooding of the port bow chain locker would have occurred.

5. At a mean draft of 95 feet and about a 17° port bow list, flooding of the port bow chain locker would have occurred.

Ballast System Performance.--The U.S. Coast Guard Marine Technical and Hazardous Materials Division studied the OCEAN RANGER's ballast pumps and piping system to determine the ballast pump's suction lift capability and the limiting forward trim to deballast the Nos. 2 and 3 ballast tanks. 18/ The following results were obtained:

17/ "OCEAN RANGER Chain Locker Flooding in Severe Waves," January 1983.
18/ "OCEAN RANGER Ballast System Analysis" July 14, 1982.

1. If there were no air leaks, the OCEAN RANGER's centrifugal pumps were capable of pumping down to about 13.4 feet below the pump's bottom impeller.

2. With a bow trim greater than 10.9°, the pumps were not capable of picking up suction to dewater ballast tanks Nos. 2 and 3 for all liquid levels.

3. At a forward trim of about 7°, the pumps would have lost suction for liquid levels less than about 75 percent full in tanks Nos. 2 and 3.

4. The pumps would have lost suction at a forward trim of about 2.7° with tanks Nos. 2 and 3 nearly empty.

Similar ballast system performance calculations 19/ were performed by the U.S. Navy David Taylor Naval Ship Research and Development Center. The results indicated that with a bow trim greater than about 10.3°, the pumps were not capable of dewatering ballast tanks Nos. 2 and 3 and that the pumps would have lost suction at a forward trim of about 3.9°. With tanks Nos. 2 and 3 nearly empty, the pumps were capable of only pumping the tanks down to about 13.8 feet below the pump's bottom impeller.

Lifesaving Equipment Performance.--The lifesaving equipment recovered from the OCEAN RANGER was analyzed by the USCG Marine Technical and Hazardous Materials Division 20/ to evaluate the performance of the equipment. Among the comments on lifeboat and liferaft design were the following:

1. The lifeboat installation drawings for the OCEAN RANGER showed that the boats would clear the transverse tube connecting port and starboard columns up to an adverse trim of 12°. Since the OCEAN RANGER is believed to have gone down by the bow, boats Nos. 2 and 4 on the stern would have had to be launched against an adverse trim. If the trim exceeded 12°, or if the boat was swinging as it approached the transverse tube, some impact damage might have occurred and might account for the damage noted to boat No. 2. The length of the falls at the level of the transverse tube would have been approximately 100 ft. which in combination with the heavy seas would have made some swinging a realistic possibility.

2. Although there was extensive damage to the lifeboats, the fibrous reinforced plastic structure was adequate. The major damage was due to the premature launch of the bow lifeboat and recovery efforts.

19/ "OCEAN RANGER Ballast Pump Analysis," December 1982.
20/ "Analysis of Lifesaving Equipment Performance," November 29, 1982.

3. After the loss of the OCEAN EXPRESS in 1976 21/, the U.S. Coast Guard approached the IMO Lifesaving Appliances Subcommittee and lifeboat builders with a proposal that would require totally enclosed lifeboats to provide an above-water escape in the event of a capsizing in the flooded condition. In most cases, this would be accomplished by the addition of flotation foam to the inside of the cover, so that it would not remain underwater in the event of a capsize. This would raise the hatches on one side out of the water, and in some cases might result in re-righting of the boat. This would prevent persons inside the boat from being trapped underneath with no way out. This approach seems to be accepted by the boat builders and will probably be part of the requirements of a revised lifesaving chapter of the International Convention for the Safety of Life at Sea (SOLAS). This feature might have allowed more of the people inside the lifeboat that capsized alongside the SEAFORTH HIGHLANDER to get out of the boat, or it might have caused the flooded boat to reright itself.

4. In order that inflatable liferafts function properly when needed, they are required to be serviced annually by an approved service station. According to the records, the rafts on the OCEAN RANGER were serviced between April 30, 1981 and July 31, 1981 by an organization in St. John's, Newfoundland. This organization was not an approved servicing facility for either C.J. Henry or B.F. Goodrich rafts 22/ and as such would probably not have had the necessary repair parts, manuals, servicing bulletins and packing instructions. A raft which is improperly serviced may not inflate or deploy properly, leading to rafts which cannot be used. There were and are no approved servicing facilities in St. John's for U.S. Coast Guard approved rafts. The closest facility was in the Boston, Massachusetts area.

The USCG report indicated that inflatable liferafts have a tendency to be carried away from the scene of an accident before survivors can reach them and that, even if the OCEAN RANGER's rafts had floated free, had inflated, and had been in the vicinity of the persons in the water, the paralyzing effect of the cold water would have made it difficult for anyone in the water without exposure protection to pull himself aboard a raft. The report also pointed out that an examination of the recovered liferafts revealed the component parts had pulled apart at the seams. Although raft seams are required to have a strength greater than the basic fabric, seams are only tested for tensile strength in the shear mode and not in the peel mode. The recovered liferafts are currently undergoing tests in a Canadian Laboratory to determine the cause of the separations.

A USCG lifesaving equipment expert conducted a detailed inspection of the recovered life preservers because many of the bodies were found face-down and some were underwater, hanging by the body strap underneath the floating life preserver. The inspection revealed that the recovered preservers fell into two groups. One group of 10 life preservers (all marked lot 1A), which were constructed in accordance with an

21/ Marine Accident Report—"Capsizing and Sinking of the Self-elevating Mobile Offshore Drilling Unit OCEAN EXPRESS near Port O'Connor, Texas, April 15, 1976" (NTSB-MAR-79-5).

22/ The two manufacturers of the liferafts aboard the OCEAN RANGER.

unapproved USCG design, were noticably heavier than the second group of preservers, which were constructed in accordance with USCG-approved designs. The second group of preservers had been produced later than the first group, which were made of polyvinyl chloride (PVC) flotation foam, rather than polyethylene (PE) foam, as prescribed for the USCG-approved design. PVC foam has a higher density, which apparently accounts for the weight difference in the two groups, and is more flexible than PE foam. In the first group of life preservers, the neck opening was designed differently and was slightly larger than the approved design and the flotation pads were thinner than on the second group of life preservers. The report notes that all three factors would contribute to the tendency to allow the wearer's head to slip out of the lot 1A life preservers.

A buoyancy test revealed that the first group of life preservers had a buoyancy loss of about 6 1/2 percent as compared to their original buoyancy. One life preserver was 1 ounce under the 22-pound minimum buoyancy required for new life preservers and two life preservers were 6 ounces under the minimum buoyancy. Some degradation of life preserver buoyancy is expected with age, and the losses on these life preservers would not be considered critical. Three life preservers in the second group were above the 22-pound minimum by 1 ounce, 27 ounces, and 28 ounces.

The USCG advised the life preserver manufacturer of its findings regarding the unapproved life preserver designs in use and that the preservers should be recalled or destroyed. The manufacturer's approval of the life preserver was suspended, pending improvement in its performance in the jump test, i.e., a person jumps into water with the life preserver on. The manufacturer instituted a voluntary recall of the life preservers from lots 1 and 1A, comprising 172 unapproved life preservers. The design of the approved life preserver also was altered so that it performed properly in the jump test. The approval certificate has been reinstated subsequently by the USCG.

The initial USCG certificate of approval for the type of life preservers used on the OCEAN RANGER was issued on February 17, 1977; however, the lot 1A life preservers were inspected and passed by a USCG inspector from the Corpus Christi, Texas, Marine Safety Office on July 15, 1976. The USCG-approval number had been stamped on the life preservers because the manufacturer had been told in advance what the approval number would be. The approval number is frequently provided by the USCG so that the manufacturer can plan equipment markings and promotional material. The lot 1A lifepreservers were probably inspected and passed by a USCG inspector based on the manufacturer's plans and specifications which ultimately were not approved. Thus, the lot 1A life preservers were a preapproval design and should not have been passed, sold, or used as USCG-approved life preservers.

The report also stated that one pre-approval life preserver was tested by USCG Headquarters personnel in May 1976. At that time, a tendency for the life preserver to come off over the wearer's head when jumping into the water was noted, but the turning moment (the force that turns the wearer from a face-down to a face-up position) appeared to be acceptable. In August 1976, the manufacturer was informed that the lifepreserver had not been approved because it lacked turning moment and that it did not keep the wearer's head far enough out of the water. However, no correlation between bodies found face-down and those wearing lot 1A or approved life preservers can be made from the available information.

<u>Canadian Diving Survey</u>.--From July 12 to August 4, 1982, the Canadian Royal Commission on the OCEAN RANGER Marine Disaster conducted a detailed diving survey on the wreck of the OCEAN RANGER. During the week of July 25 to July 30, a Safety Board investigator observed a portion of the diving operation. By July 26, the entire

lower structure of the OCEAN RANGER between the keel and about the 60-foot level had been surveyed. No structural damage was noted, except for the bow of each lower hull and the main longitudinal girder at the 134-foot level near the after starboard column. No visible penetrations of the lower hulls or columns were detected. The sea chest strainers on both lower hulls were removed and both manual gate valves were found closed.

The amount of trapped air in each lower hull compartment, including the pumprooms, propulsion rooms, the ballast, drill water, and fuel oil tanks, and the chain lockers in the four corner columns was determined by using two types of electronic devices. In addition, the tanks were also sounded by striking the exterior hull with a hammer with an attached microphone so those on board the diving vessel could also hear. The interior void space in each lower hull was not sounded. The tanks in the lower hulls are about 24 feet deep and the bottoms of the chain lockers are about 35 feet above the keel. The results are as follows:

(Port Hull) Tank	Ullage (inches)	(Starboard Hull) Tank	Ullage (inches)
PT-1	0	ST-1	0
PT-2	0	ST-2	0
PT-3	0	ST-3	0
PT-4	0	ST-4	4
PT-5	36	ST-5	60
PT-6	72	ST-6	72
PT-7	60	ST-7	36
PT-8	12	ST-8	36
PT-9	12	ST-9	36
PT-10	90	ST-10	24
PT-11	12	ST-11	6
PT-12	6	ST-12	12
PT-13	24	ST-13	0
PT-14	12	ST-14	24
PT-15	0	ST-15	12
PT-16	21	ST-16	12

Compartment	Ullage (Inches)	Compartment	Ullage (Inches)
Port Pumproom	54	Starboard Pumproom	102
Port Propulsion Room	84	Starboard Propulsion	144
Forward Port Column Chain Lockers	0	Forward Starboard Column Chain Lockers	1
After Port Column Chain Lockers	7	After Starboard Column Chain Lockers	6

The divers burned out one of the broken portlight frames (D on figure 3) from the ballast control room in the starboard column and entered the ballast control room through a 30-inch hole. Inside, they found the doors to the lower portion of the control panel open. The manual brass actuating rods were inserted in many of the valve control solenoids for the individual tank valves in both the port and starboard hulls. All but one of the solenoids with the rods inserted was found in the activated position. All 64 solenoid valves, together with the switch panels and the mimic boards, were removed. A preliminary examination revealed a broken lead-in wire on the P-32 switch for the remote controlled port sea chest valve and an "x" was marked on the top of the panel to the switch. The P-19 switch for the drill water discharge valve was burned at the base of the switch around the wires on the closed side of the switch. An "x" was marked next to it on the panel. The P-27 switch for the stop valve in the ballast discharge line to the port ballast tank manifold also had an "x" marked next to it on the panel. The clear plastic covers to the three starboard ballast pump control switches, two port ballast pump control switches, and both the port and starboard drill water pump switches were missing. The frame of the second broken portlight (C on figure 3) was unbolted and brought up. It was noted that all glass fragments had been removed from around its edge. Various documents were also removed and preserved.

Documents recovered from the ballast control room indicated that the liquid levels in the tanks on February 14 were the same as those assumed in the May 1982 stability study, except for PT-2 which was shown as 68 percent full rather than the assumed 72 percent full; PT-13 which was shown as 53 percent full, rather than 47 percent full; PT-14 which was shown as 68 percent full, rather than 88 percent full; ST-4 which was shown as 55 percent full, rather than 61 percent full; ST-12 which was shown as 36 percent full, rather than 17 percent full; ST-13 which was shown as 36 percent full, rather than 30 percent full; and ST-14 which was shown as 57 percent full, rather than 87 percent full. A cursory inspection of other recovered documents revealed that they were old documents and notes. Any other current logs or papers which were laying out on the desk of equipment in the ballast control room are probably buried in the foot of barite reported by the divers to be covering the overhead which now is upside down.

Currently, the Royal Commission is conducting tests and studies of the underwater video tapes, still pictures, other recovered documents, and various pieces of equipment recovered from the OCEAN RANGER. The results of these tests and studies have not been released.

Other Information

U.S. Coast Guard Certificate Of Inspection.--Subchapter I-A of Title 46 of the U.S. Code of Federal Regulations prescribes rules for the design, construction, equipment, inspection, and operation of mobile offshore drilling units operating under the U.S. flag. Subpart B prescribes the rules for inspection and certification. 46 CFR 107.215(b) states:

> The master, owner, or agent of a certificated unit operating in international service may apply for renewal of a Certificate of Inspection by submitting a completed Application for Inspection of U.S. Vessel Form CG-3752, to the appropriate Officer in Charge, Marine Inspection, at least 60 days before the expiration date that appears on the unit's unexpired Certificate of Inspection.

Title 46 USC 391 states in part:

> Steam vessels not carrying passengers; biennial inspection
>
> (b) The head of the department in which the Coast Guard is operating shall require the Coast Guard to inspect before the same shall be put into service, and at least once in every two years thereafter, the hull of each steam vessel, not carrying passengers; to determine to its satisfaction that every such vessel so submitted to inspection is of a

> structure for the service in which she is to be employed, has suitable accommodations for the crew, and is in a condition to warrant the belief that she may be used in navigation, with safety to life, and that the vessel is in full compliance with the applicable requirements of this title or Acts amendatory or supplementary thereto and regulations thereunder; and if deemed expedient, to direct the vessel to be put in motion or to adopt any other suitable means to test her sufficiency and that of her equipment.

Title 46 USC 361 states that every vessel subject to inspection, propelled in whole or in part by steam or by any other form of mechanical or electrical power shall be considered a steam vessel. On March 9, 1982, before the U.S. House of Representatives Committee on Merchant Marine and Fisheries, the Chief of the USCG Office of Merchant Marine Safety stated that 46 USC 435 requires that U.S. flag vessels have a valid Certificate of Inspection to avoid being subject to a penalty and that the owner is responsible for keeping the certificate valid. He further stated that the USCG does not keep track of when certificates expire but relies on the owner to inform the USCG of the certificate's expiration. There are approximately 10,800 U.S. certificated vessels with about 1,900 of those vessels over 1,600 gross tons. The USCG is implementing a Marine Safety Information System (MSIS) which will computerize information concerning all U.S. certificated vessels. MSIS will contain information on the last USCG inspection of a vessel and will be capable of providing lists of vessels due for inspection.

Title 46 CFR 107.269 states that the USCG reinspects a MODU between the 10th and 14th months after the month in which the certificate is issued to determine if the unit meets the requirements of the Certificate of Inspection. Installation tests for lifeboats, davit-launched liferafts, carbon dioxide extinguishing systems, and sliding watertight doors are not included in the reinspection process. On August 7, 1980, the Commandant of the Coast Guard made discrectionary the reinspections of cargo and miscellaneous vessels by USCG marine inspection offices. In January 1981, the USCG Commandant permanently discontinued reinspections of cargo and miscellaneous vessels, except in Alaska and Hawaii. On January 7, 1982, the USCG Commandant discontinued reinspections worldwide for cargo and miscellaneous vessels and MODU's and stated that the Coast Guard regulations would be amended accordingly. However, on April 6, 1982, reinspections of MODU's on the U.S. outer continental shelf were again reinstated by the USCG Commandant. Because of budgetary contraints, reinspections of MODU's in international service have seldom been conducted since the regulations affecting MODU's became effective in 1978.

MODU Manning Standards.--The OCEAN RANGER was manned according to the terms and conditions set forth in the drilling agreement between the operator (MOBIL) and the contractor (ODECO). This agreement specifically listed the number and type of personnel in addition to other operational requirements. Other than the master, those persons required by the USCG Certificate of Inspection (see figure 7) were not specifically addressed.

Current USCG regulations do not address the minimum manning standards and qualifications required for the operation of MODU's, except the minimum number and qualifications of certificated lifeboatmen, and to require that the owner designate an individual to be the master or person-in-charge. In the USCG Marine Safety Manual (CG-495), Chapters 50, Part 50-8, and 55 are reserved for future manning requirements for MODU's. The present manning requirements for individual MODU's are established by local USCG Marine Inspection Offices.

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Certificate of Inspection

Name: OCEAN RANGER — Official number: 635681 — drilling vessel

Gross tons: 14,913 | Net tons: 12,032 | Length: 398' | Home port: New Orleans, Louisiana

Year built: 1976 | Place built: Hiroshima, Japan | Hull construction: Steel

Operator: Ocean Drilling and Exploration Company — Operator's address: P.O. Box 61780, New Orleans, Louisiana 70161

Owner: Ocean Drilling and Exploration Company — Owner's address: P.O. Box 61780, New Orleans, Louisiana 70161

The inspection of the above named vessel having been completed at Providence, Rhode Island on the 27 day of December, 19 79, I hereby certify that said vessel is in all respects in conformity with the applicable vessel inspection laws and the rules and regulations prescribed thereunder. The following complement of licensed officers and crew is required to be carried. Included in which there must be [illegible] Certificated Lifeboatmen and [illegible] Certificated Tankermen.

In addition the vessel may carry [illegible] other persons in the crew [illegible] passengers [illegible] persons in addition to the crew, and 87 Industrial Personnel. Total persons allowed [illegible]

Route permitted and conditions of operation: [illegible]

EQUIPMENT AND INSPECTION DATA

Lifesaving equipment provided for 100 persons; 30 ... 50 persons; 250 ...

Drydock: 26 December 1979 (temp) ... Special survey due 1 June 1980 ... Propulsion: Motor - diesel electric ... 14,200 ... Diesel ... 3,575 ... KW

Los Angeles ... 200 psi

Fire extinguishers: 12 B-II, 6 B-III, 2 B-V, 2 C-I, 27 C-II ... 2050 ...

PERIODIC RE-INSPECTION — Date | Inspection zone | Signature

R.A. SUTHERLAND, CAPT., USCG
Officer in Charge, Marine Inspection

PROVIDENCE, RHODE ISLAND
Inspection Zone

Figure 7.--U.S. Coast Guard Certificate of Inspection.
(Reproduced by the National Transportation Safety Board.)

Under the conditions of operation set forth in the OCEAN RANGER's Certificate of Inspection, when the drilling unit is navigated for less than 16 hours in a 24-hour period, the minimum crew required was one master, one mate (industrial license), one radio operator, three able seaman (AB), one ordinary seaman (OS), one chief engineer (industrial license), one assistant engineer (industrial license), two oilers, and seven certificated lifeboatmen -- two for each of the two 50-person lifeboats and one each for three of the ten 20-person inflatable liferafts. USCG regulations required two lifeboatmen for each lifeboat since the lifeboats had a capacity for more than 40 persons. The USCG Marine Inspection Office which issued the certificate required that three additional lifeboatmen be on board the drilling unit to operate the liferafts.

When the drilling unit was moored, the minimum crew required was one master (industrial license), two able seamen, and one ordinary seaman, and four certificated lifeboatmen -- two for each of the two required lifeboats. The maximum number of persons, including industrial personnel, permitted on board the vessel by the Certificate of Inspection was 100. The OCEAN RANGER's Certificate of Inspection also required licensed marine engineers (industrial) in the several variations of underway status which it addressed; however, none were required when it was moored at the drilling site.

"Industrial license" is not defined in USCG regulations nor are there any published standards regarding their issuance. Special licenses are issued by individual USCG Marine Inspection Offices to experienced industrial personnel 23/ so that those personnel can satisfy the licensed manning requirements of the USCG Certificate of Inspection for certain modes of operation. Generally "industrial licenses" are permitted for all modes of operation on a nonself-propelled MODU. Generally, on self-propelled MODU's which navigate for more than 16 hours but less that 72 hours, a master with an unlimited license is required, but all other deck and engine licensed personnel are permitted to have "industrial licenses." For voyages over 72 hours, both the master and mates are required to have unlimited licenses.

ODECO's operations manager from St. John's, who was responsible for hiring personnel on the rig, testified that he did not keep a list of those crewmembers having seaman's documents and that he did not know of any such list being available. He also stated that the rig's safety man (IRR) and the master were supposed to notify him if they needed properly documented personnel to fulfill the requirements of the USCG Certificate of Inspection. When questioned about whether he had any way of knowing who in the crew had the necessary documents, he stated: "There is no way except going around and asking, finding out from the individuals which I would do on occasion, especially before the rig moves." Various classifications, such as roustabouts, drillers and floormen, of the 46-man drilling crew aboard the OCEAN RANGER do not indicate whether the individual should possess a USCG document.

In addition to the operating crew of the drilling unit, 38 subcontractor employees performed various functions related to the drilling operation, e.g., drilling engineers who were responsible for monitoring core samples, weather observers, divers, a geologist, test equipment operators, hotel staff. There were also MOBIL representatives who dealt with the industrial personnel.

23/ A term used to describe individuals who are not seamen nor passengers in the traditional sense but are on board for the sole purpose of carrying out the industrial business or functions of the MODU.

At the time of the accident, ODECO did not have any written instructions for the person-in-charge, the master, or the control room operators regarding their marine responsibilities. However, the USCG-approved operations manual for the OCEAN RANGER stated that:

> The barge master [master] is the "barge mover" and is in complete charge of the unit while it is being prepared for a move and is in the process of moving. The barge master is responsible for the stability of the unit at all times.
>
> During all industrial operations, the toolpusher is designated as the person in charge of the unit. He becomes person in charge once the unit is relocated.

According to 46 CFR 109.109, the toolpusher, although unlicensed, has the responsibility to: " (1) Ensure that the provisions of the Certificate of Inspection are adhered to; and (2) Be fully cognizant of the provisions in the operating manual required by the 46 CFR 109.121." (See appendix D.) In addition, the toolpusher is responsible for tests, safety drills, and inspections (46 CFR 109 Subpart B); the operation and stowage of safety equipment (Subpart C); reports, notifications, and records of equipment tests (Subpart D); the required station bill (Subpart E); the safe operation of cranes and powered industrial trucks (Subpart F); and other miscellaneous items, such as stowage of hazardous materials, maintaining required navigational information and prevention of pollution (Subpart G). The OCEAN RANGER's toolpusher did not hold any USCG seaman's documents, particularly a lifeboatman's certificate, although he was assigned to be in charge of the No. 1 lifeboat during an emergency. His employment history did not indicate any formal training in the marine aspects of the drilling operation, such as stability and ballast control. In the ordinary progression of training aboard an ODECO drilling rig, such as the OCEAN RANGER, a toolpusher can reach his position without any type of marine training. Toolpushers usually gain their drilling experience from working on various types of rigs, such as jackup rigs, drilling ships, land-based drilling operations, but may have had little or no marine experience before assignment as person-in-charge of a MODU.

Command of self-propelled drilling units, such as the OCEAN RANGER, alternates between the master and the toolpusher, depending on whether the rig is in transit or moored over a drilling site. Traditionally the master of a vessel is in command, regardless of its location, whether underway or moored. Moored MODU's, on the other hand, are regarded as an industrial activity by the USCG and the person-in-charge is not required to have a maritime background or possess a license or document attesting to his experience either on ships or MODU's.

The master of the OCEAN RANGER was a licensed person with knowledge of the marine aspects of the MODU, although he may not have been familiar with particular systems when he first reported aboard. Many masters aboard MODU's are older, possibly retired seafarers who, because of their expertise and maritime experience, are employed to command the MODU's when in transit. When the MODU's are on the drilling site, however, the operating conditions change and the marine portion of the operation becomes secondary to the drilling activity. The command structure changes and the toolpusher becomes the person-in-charge.

While the toolpusher may defer to the master in any marine related matter he still retains control as the person-in-charge. A former master of the OCEAN RANGER stated that, while the rig was positioned over the drill site, the toolpusher would have the ultimate authority to order the abandonment of the rig, especially if it was due to a well problem, such as a blow out 24/ or fire. He also said that in marine related emergencies, such as weather or anchor problems, the toolpusher would call upon the master's expertise in these emergencies and they would agree on the action to be taken. MOBIL's drilling foreman would also be consulted in any emergency.

With the MODU moored over the drill site, there is little difference between the marine operating requirements of a self-propelled and a nonself-propelled semisubmersible MODU; however, the USCG regards them differently. The USCG does not require a nonself-propelled semisubmersible MODU to have a licensed master although the person-in-charge of the ballast system performs the same tasks as the licensed master of a self-propelled unit when moored. This person falls under the broad general classification of "industrial person" as perceived by the USCG. Whether on a self-propelled or nonself-propelled MODU, the person-in-charge is responsible for the safe operation of the ballast system and the other safety items enumerated in the USCG regulations. In the daily routine, with the rig positioned over the well, the master of the OCEAN RANGER was responsible for loading material and liquids, exercising his control through the control room operators, and maintaining the proper trim and required stability. These routine matters were coordinated with the toolpusher who would assign the necessary manpower.

The ballast control room operator is responsible for maintaining the watch in the ballast control room and is under the supervision of a licensed master on a self-propelled MODU, such as the OCEAN RANGER; nevertheless he is considered an "industrial person." The ballast control room operator is usually recruited from the ranks of those persons working on the drill floor, usually starting in the roustabout level. If he shows interest in becoming a control room operator, he is allowed to familiarize himself with the operation on his own time. If he shows potential and is recommended by the master and/or a control room operator, the toolpusher will permit him to spend a portion of his workday in the control room on company time. His training sessions consists of spending time in the ballast control room and receiving instructions from the senior control room operator. Control room operators usually have little or no maritime background in ship stability or other marine related subjects. At the time of the accident, ODECO did not have any minimum training standards that applied to prospective control room operators although it operated a stability school in New Orleans, Louisiana, to which some control room operators were sent. USCG regulations do not identify the control room operator as a person who is required to have a license or a document, apparently relying instead on the adequacy of the supervision of a licensed master on self-propelled MODU's and an unlicensed and undocumented barge engineer on nonself-propelled rigs. Testimony by one of the alternate control room operators revealed that when he was assigned as the operator of the ballast control room on the OCEAN RANGER, he had spent a period of 1 week working full time with a senior control room operator and before that, a period of 2 to 3 hours of a 12-hour workday for about 5 weeks with the senior control room operator. In the course of his training, he had never pumped the rig to change draft. He had used the ballast pumps to change trim or heel to compensate for weight changes but had never exceeded 1° to $1\ 1/2^{\circ}$. His knowledge of stability came largely from familiarizing himself with the operating manual and learning the steps necessary to complete the daily report forms for determining the stability conditions of the rig.

24/ An accidental escape of oil or gas from a well during drilling.

USCG regulations which established the requirements for mobile offshore drilling units were first adopted and published in 1978. However, the manning standards for these drilling units have never been addressed, other than the requirement that self-propelled units shall have a licensed master and that a minimum number of persons aboard be able seamen, ordinary seamen, and certificated lifeboatmen. In 1978, the USCG completed a 2-year study of MODU operations 25/ to provide a basis for establishing marine-related qualifications requirements for MODU personnel, which included semisubmersible units, such as the OCEAN RANGER. The Federal Register, Vol. 47, No. 209, dated October 28, 1982, which contains the USCG's current and projected rulemakings, does not show any regulatory project in process for establishing personnel qualifications or manning standards on MODU's.

MODU Crew Qualifications.--In accordance with the policy of the Canadian Government, about 65 percent of the persons employed on the OCEAN RANGER by ODECO were Canadian citizens. About one-third of the ODECO personnel were U.S. citizens. Under the terms of the drilling agreement between MOBIL and ODECO, the drilling contractor was obligated to employ residents of Newfoundland wherever possible. Most of the Canadian citizens had seaman's background but lacked oil field experience. MOBIL was responsible for the cost of training unskilled persons if it was necessary to employ them in order to comply with any law or requirement.

The ODECO operations manager in St. John's interviewed local people for the various positions to determine their qualifications. When he was unable to find local persons with the proper experience, the ODECO New Orleans office hired experienced people from the Gulf of Mexico area. The ODECO operations manager stated that he had written a letter to the USCG requesting permission to use qualified Canadian citizens to fulfill the manning requirements of the Certificate of Inspection. However, before a reply was received, he had used Canadian citizens to fill some positions but had kept no record of their qualifications. Key personnel, such as the master, the toolpusher, the industrial relations representative, the drillers, the senior mechanic, and the senior electrician—persons who had previous experience on ODECO rigs—were hired through the New Orleans office. The master, however, was hired for that position based on his USCG license, which was sufficient to qualify him for the position. The ODECO operations manager said that, "If a master came with full licensing, I wouldn't be qualified to question his license or anything." He also stated that, "If he has the right papers, he should be qualified to look at the ballast book, study the book, and be able to ballast the rig."

At the time of the accident, the master of the OCEAN RANGER was expected to supervise the ballast control room operators. He had reported for duty on board the drilling vessel on January 26, 1982, at which time he relieved the alternate master. Shortly afterward, the alternate master disembarked from the rig on the same helicopter on which the relieving master had arrived. A former control room operator who had served on the OCEAN RANGER for 3 1/2 years testified that there was no overlap or break-in period for relief masters.

USCG regulations do not require the person-in-charge to be licensed or documented. The toolpusher, who was designated as the person-in-charge, was hired because of his qualifications in the drilling business. His knowledge of the drilling portion of the rig and his ability to lead a drilling gang were the primary considerations for employment. He

25/ Report No. CG-D-76-78, Functional Job Analysis of Mobile Offshore Drilling Unit Operations, Vol. I and II.

was not schooled in stability nor did he have intimate knowledge of the ballast control system. He was expected to exercise complete control of all areas of the rig. A former toolpusher, who served on the OCEAN RANGER after it transferred to U.S. registry, testified that he could not recall reading the USCG regulations that related to MODU's. He testified that, although he was the person-in-charge, he was unaware of the responsibilities and obligations that the regulations imposed on him. As an unlicensed "industrial person," the USCG had no means to insure that he observe the regulations, such as the suspension and revocation proceedings which can be brought against licensed, certificated, or documented persons.

State-of-the-Art in Lifesaving Systems.--In recent years, progress has been made toward a new concept in the design and launching of survival craft from larger type vessels, such as very large crude carrier (VLCC), and from semisubmersible platforms. In 1973, the Norwegian Maritime Directorate established a project to develop a better lifesaving device for large vessels without limiting the study to existing rules and regulations. A free fall launching system was developed that eliminated the possibility of the lifeboat being thrown against the ship's side during or after launching. The free fall system utilized a special lifeboat which was designed to seat the passengers facing aft in padded seats, strapped in six-point safety belts with their backs toward the direction of launch. In 1978, the Norwegian Maritime Director approved the free fall system for use aboard the bulk carrier TARCOOLA. The system has also been installed on a drilling rig similar to the OCEAN RANGER, the DYVI DELTA, now drilling in the North Sea. The USCG has not evaluated this type of launching system.

Currently, the IMO is considering a revised Chapter III, Lifesaving Appliances, to the 1974 International Convention for the Safety of Life at Sea. If accepted by the member nations of IMO, Chapter III will require that the releasing mechanism for lifeboats be capable of releasing the waterborne lifeboat under any condition of loading, from no load to a load 1.1 times its rated load. The revised Chapter III requires covered lifeboats, permits free fall launching systems, and requires that each lifeboat be equipped with at least three exposure suits and some thermal protection for each crewmember. Chapter III would also require each lifeboat on a cargo ship to have an EPIRB and portable two-way radiotelephones.

Canadian offshore drilling regulations require a standby boat to be assigned to each drilling rig operating on the Canadian outer continental shelf. Both Norway and the United Kingdom require standby boats for MODU's operating in the North Sea. The standby boats, which are usually supply vessels, have been successful in withstanding the severe weather encountered on the Grand Banks, but were not designed specifically as rescue vessels. "Scramble" nets have been used in the past to aid in getting people aboard the boat but require participation by those being rescued. Because the effects of hypothermia quickly render a person helpless in the colder water, such as those of the Grand Banks, several European marine supply companies have developed a rescue basket for use by standby boats to recover persons in the water. One such device, fabricated from aluminum mesh, is designed to be thrown overboard and to drift freely on its own. Persons in the water climb into the basket which can then be lifted by either a helicopter or a deck crane of a supply vessel. Another device incorporates a mesh-type basket that is suspended from a deck crane of a supply vessel and partially sinks into the sea until a buoy, incorporated into the design, gives it buoyancy. Persons in the water, even those partially disabled, can easily enter the partially submerged basket. The deck crane holds the device well clear of the vessel's side. The basket can also be used to "scoop" an unconscious person from the water.

Canadian Regulatory Control.--Although the OCEAN RANGER was a U.S. flag vessel operating in international waters, it was drilling within Canada's 200-nmi economic zone. Before MOBIL could begin drilling operations, it was required to obtain a Drilling Program Approval as specified in the 1980 Canada Oil and Gas Drilling Regulations. These regulations include requirements for standby craft, lifesaving equipment, meteorological observers, and contingency plans. (See appendix E.) The Province of Newfoundland and Labrador also exercised some control over drilling operations. On July 6, 1982, Newfoundland published Offshore Installations Regulations, including design, construction, and survey requirements.

ALEXANDER L. KIELLAND.--The ALEXANDER L. KIELLAND was a semisubmersible MODU which was being used as a hotel-type accommodation platform when it capsized and sunk on March 27, 1980, in the North Sea with the loss of 212 persons. Eighty nine persons were rescued. At the time of the accident, the wind was 31 to 39 knots and the waves were 20 to 26 feet high. Although the cause of the accident was a fatigue fracture which resulted in one of the KIELLAND's five columns breaking off, there are similarities between it and the OCEAN RANGER accident. The following are excerpts from "Report No. 67 to the Storting (1981-82) The 'ALEXANDER L. KIELLAND' Accident" by the Norwegian Ministry of Local Government and Labour:

> When column D was lost the ALEXANDER L. KIELLAND at once heeled over until the angle of heel was about 30-35°. Then the platform stabilized in the sea. From this position it continued slowly to heel and to sink until it turned up-side down about 20 minutes later.
>
> The main reason for this unintended heel is that the platform was not designed to have sufficient stability when it loses a major buoyancy element (column). Neither did any regulation require stability for such circumstances at the time when ALEXANDER L. KIELLAND was approved.
>
> When ALEXANDER L. KIELLAND heeled over downflooding water took place at once in the trunks,which include the shafts of the lifts in column B and column C and possibly also in oblique bracings and the dry tank at the top of column E. Filling of the trunks and possibly also the oblique bracings was not sufficent to make ALEXANDER L. KIELLAND capsize. In order that that should happen also more than half of the deck volume would have to be filled up with water. On the condition that filling of the deck volume to such a degree should occur only by flooding through open drain valves in the lower deck, the capsizing would have taken place more than an hour after the initial heeling. When ALEXANDER L. KIELLAND turned up-side down just after about 20 minutes flooding of the deck volume must have taken place also through other openings in the deck - doors or ventilators. However, the possibility that holes caused by damage have been downflooding openings cannot be completely ruled out.

* * * * *

Survival suit was not prescribed as life-saving appliance. Only the crew and some of the hotel guests possessed such equipment. 8 persons managed to put on survival suits. 4 of them were rescued. 4 of the perished and 3 of the survivors had not managed to close the zips on their suits properly.

On board "Alexander L. Kielland" there were 7 covered lifeboats, each with seats for 50 men. 4 of the lifeboats were lowered without particular problems. On the other hand, problems occurred with the release of the lifeboat hooks. The hooks which were equipped with simultaneous release can not be released as long as they are under load and this was difficult to avoid due to the rough sea on the day of the accident. For this reason 3 of the boats were blown against the platform and crashed. On the fourth boat the afterpart of the wheelhouse was crashed. Through the opening caused by the crash a man managed to release the after hook by hand. Before that someone had succeded in one way or another to release the forward hook. A fifth boat came down on the water bottom-up when the platform capsized. The hooks had been released in some way or another. People in the boat and people outside it managed by common efforts to turn it on even keel.

With regard to the two lifeboats which were utilized there were 26 men on board the first one. A few hours after the accident these people were taken up by a rescue helicopter. In the other boat there were 14 persons when it came down to the water. In addition 19 persons were taken up in the boat from the sea. Of the persons on board 12 men were later on taken on board a supply boat while the other 21 persons were rescued by helicopters. Those who were on board the lifeboats claimed that they felt heavily chilly.

On board "Alexander L. Kielland" there were inflatable rubber rafts both for lowering by crane and for throwing over board with a capacity for 400 men all together. Attempts were made to release some rafts. This was not successful. Some rafts were, however, released directly due to the list of the platform. On some of them the inflatable system was activated when the rafts hit the water. 3 men managed to board these rafts. These men were later on rescued by supply vessels. Inflatable rafts were also thrown over board from "Edda 2/7C". 26/ All together 9 men managed to board one of these rafts. They were all hoisted up by a British rescue helicopter. From another raft from "Edda 2/7C" 4 men were rescued by a supply vessel.

Of all those who must have ended up in the sea when the "Alexander L. Kielland" capsized and who were not taken on board lifeboats or managed to board rafts, only 14 persons were rescued. Of these 7 persons managed to swim up to "Edda 2/7C" and were taken on board by means of personnel basket. The other 7 were taken up by supply vessels either directly from the sea or from wreckage which they clinged to.

26/ "Edda 2/7C" was a production platform moored near the ALEXANDER L. KIELLAND.

Most of those who were taken up from the sea, were rescued within half an hour at a maximum. One man which had put on both survival suit and a lifejacket was lying in the sea, however, for 2 hours and 35 minutes.

In accordance with the approved emergency plan for the Ekofisk field 3 standby vessels are to be placed in the field. Each stand-by vessel shall be stationed in such a position that it can reach each of the platforms which it is intended to serve within the course of 20-25 minutes. The stand-by vessel for "Alexander L. Kielland" did not arrive at the place of the accident before nearly an hour after the loss. No survivors were rescued by the stand-by vessel.

ANALYSIS

Capsizing

About 1900 on February 14, the senior MOBIL drilling foreman aboard the OCEAN RANGER reported that a portlight in the ballast control room had broken and that there was some water in the control room. Subsequent communications indicated that the situation had been corrected. The first indication of a serious problem did not come until 0052 on February 15, about 6 hours later, when the radio operator on the OCEAN RANGER transmitted a distress message stating that the OCEAN RANGER had a severe list and that it needed immediate assistance. Between 0052 and 0130, when the OCEAN RANGER radio operator sent the last known radio message that the crew was going to the lifeboat stations, no specific information concerning the nature of the OCEAN RANGER's problem was transmitted. However, the investigation revealed that during this period the crew was attempting to isolate the problem, that all countermeasures were ineffective, that the OCEAN RANGER was experiencing a list of 10° to 15°, and that the list was progressing. Since MODU personnel use the term list to mean a deviation from the horizontal in any direction and since some radio transmissions modified the term "list" by saying that the OCEAN RANGER was down by the bow or listing to port, the reported list was probably a combination of trim by the bow and a heel to port.

From 0130 to about 0300, the OCEAN RANGER's list continued to increase. Two crewmembers of the BOLTENTOR testified that, as they observed the OCEAN RANGER between 0245 and 0300, the MODU had a 35° list, but they could not determine in what direction. At 35°, the upper deck of the upper hull would have been submerged and, under the sea conditions that existed, flooding into the upper hull already would have begun. At 2330 on February 14, the OCEAN RANGER, which was on a heading of 311,° had reported 33-foot-high wind waves from 270° and 22-foot swells from 230°. With a port bow list, the OCEAN RANGER would have been listing into the oncoming seas. Although the OCEAN RANGER's upper hull was watertight for a distance of 30 feet inboard from its sides, there were large openings to the chain lockers in each corner column. At a 35° list and a mean draft of about 60 feet or greater, the port bow chain locker would have filled and the internal compartments within the upper hull would have flooded because of the 33-foot waves; this flooding, in turn, would have caused the OCEAN RANGER to capsize by the bow and eventually to sink.

Based on the testimony of the master of the NORDERTOR, the Safety Board determined that, sometime between 0305 and 0310 on February 15, the master saw the OCEAN RANGER's contact disappear from the NORDERTOR's radar screen. The master also stated that, seconds after the contact disappeared from the radar screen, two small contacts appeared in the same area and then they also disappeared from the radar screen.

The Safety Board believes that the two small radar contacts were probably the OCEAN RANGER's lower hulls extending above the surface as the MODU capsized.

The OCEAN RANGER came to rest upside down about 500 feet to the southeast of its anchored position on a heading of 117°. Since the 408-foot-long lower hulls capsized in only 260 feet of water, the damage observed on both lower hull bows in the post accident inspection probably occurred as the OCEAN RANGER capsized. A side scan sonar survey conducted in February 1982 showed that the anchor cables in the fore and aft direction had parted while at least one transverse anchor cable to each corner column remained intact, further indicating that the OCEAN RANGER capsized by the bow.

The 10° to 15° List

The evidence that there was a 10° to 15° list about 0100 on February 15 was consistent: radio transmissions to shore and intercepted intraship radio conversations from the OCEAN RANGER during the afternoon and evening of February 14, underwater videotapes and a side scan sonar survey taken in late February and early March 1982, a detailed diving survey during July and August 1982, and stability and seakeeping calculations performed after the accident all pointed to this conclusion. The most likely cause of the list was a transfer of water from the after ballast tanks in the lower hulls to the forward empty or partially empty forward ballast tanks, or the flooding of empty or partially empty forward ballast tanks in the lower hulls through the ballast system. The stability and seakeeping calculations indicated that, except at extreme drafts, neither the port bow chain locker nor any upper hull internal compartments would have flooded until the OCEAN RANGER had a port bow list in excess of 10° to 15°. The stability calculations indicated that, at the 80-foot operating draft, the transfer of all ballast water in the lower port hull to the forward ballast tanks, allowing for the restraining effect of the mooring system, would have resulted in a port bow list of 23°. The calculations also indicated that the flooding of all empty lower port hull ballast tanks, allowing for the restraining effect of the mooring system, would have resulted in a port bow list of 21° at a mean draft of 94 feet. A smaller ballast transfer or a lesser amount of flooding would have been needed to cause the reported 10° to 15° list. However, exactly how and when the the liquid transfer or flooding began could not be determined. The underwater surveys showed there was no structural damage to the lower hulls or columns which would have lead to the ingress of water. Both manual gate valves were found closed when the sea chest strainers on both hulls were removed by divers. However, a significant amount of water was found in the tanks of both lower hulls.

Before 1900 on February 14, the only problem reported by the crew of the OCEAN RANGER was a difficulty in disconnecting the drill pipe because the compensator hoses were blowing out the side of the derrick. Because of the deteriorating weather conditions, the crew of the OCEAN RANGER decided to shear the pipe. At 1858, the OCEAN RANGER's toolpusher reported that the drill pipe had been sheared, that the marine riser was disconnected, and that there were no problems.

About 1900, MOBIL's senior drilling foreman aboard the OCEAN RANGER called the MOBIL drilling foreman on the SEDCO 706 and informed them that a portlight had been broken in the OCEAN RANGER's control room but that there were no problems. Between 1930 and 1945, the SEDCO 706 barge engineer and control room operator overheard broken radio transmissions from the OCEAN RANGER to the effect that there was water and glass on the control room floor, that all valves were opening on the portside, that the public address system was inoperative, and that crewmembers were getting electrical shocks. The SEDCO 706 barge engineer and control room operator stated that the radio transmissions seemed to be internal communications aboard the OCEAN RANGER between the VHF radio in the ballast control room and hand-held VHF radios somwhere else on the rig. One of the MOBIL drilling foremen in the SEDCO 706 control room overheard similar transmissions but believed that they were before 1900. Since the MOBIL foreman did not check the time, the Safety Board believes the overheard transmissions he heard in fact were made between 1900 and 2000. None of these radio communications or overheard transmissions indicated that the OCEAN RANGER had a list, and at 2044, MOBIL's senior drilling foreman on the OCEAN RANGER told the MOBIL superintendent in St. John's that there were no problems as a result of the broken portlight. However, between 2100 and 2200, more broken transmissions from the OCEAN RANGER were overheard by the SEDCO 706 barge engineer, the SEDCO 706 control room operator, and the master of the BOLTENTOR. They heard that valves were opening on their own, that an electronic technician was needed in the control room, and finally that everything was cleaned up and normal. At 2200, the MOBIL senior drilling foreman aboard the OCEAN RANGER assured the MOBIL superintendent that there were no problems as a result of the broken portlight in the control room and that all equipment was functioning normally. Exactly, what the MOBIL drilling foreman meant by this statement could not be determined. Except for a routine weather report at 2330 that gave no indication of any problems aboard the OCEAN RANGER, there were no further radio communications or intercepted transmissions until the distress call at 0052.

The underwater video tapes taken in March 1982 and the July 1982 diving survey both show two broken portlights. One portlight was behind the tank gauges (portlight D, figure 3) and the other one was the after portlight on the portside near the front of the ballast control console (portlight C, figure 3). With the OCEAN RANGER on a heading of 311°, the forward broken portlight would have been facing in the direction of about 245°, and the after portlight would have been facing in the direction of about 175°. The weather observer aboard the OCEAN RANGER reported that the wind and waves shifted from 220° to 270° between 1730 and 2330 on February 14. From the radio communications and the intercepted transmissions, it was not possible to determine whether both portlights or only one portlight broke around 1900, nor was it possible to determine from the intercepted transmissions whether the second portlight broke between 2100 and 2200. However, the intercepted transmissions indicated that the crew of the OCEAN RANGER was experiencing some problems with the control panel. If portlight C had broken between 1900 and 2200, water may have splashed on the ballast control panel and caused an electrical malfunction. Any water entering through portlight D would be partially deflected by the gauge panel and should not have immediately affected the control console. The cause of the breaking of the portlights could not be determined specifically; it may have been caused by hydrostatic pressure, debris or ice in the water, or hoses or lines swinging in the wind. The Safety Board believes that the USCG should evaluate the adequacy of existing standards for portlight installations in those ballast control rooms located in columns of semisubmersible MODU's.

With the manually operated gate valves in the sea chest inlets normally left open, it would have taken only a few minutes for the OCEAN RANGER to have developed a significant list if the control panel malfunctioned or if the controls were operated incorrectly to cause the valves between the lower hull tanks and the sea chest to open. The overheard conversations between 1900 and 2000 regarding valves opening and closing by themselves suggest an electrical malfunction of the control panel. The first action the control room operator should have taken was to close all valves. However, there may have been sufficient time before he was able to close the valves to allow sea water to enter empty or partially empty tanks forward or for water to gravitate from after ballast tanks to forward ballast tanks, causing a port and list. The second series of intercepted transmissions between 2100 and 2200 may have followed the breaking of a second portlight or an attempt by the crew to reenergize the control panel after drying out the electrical components. While the second series of events may have aggravated existing list or flooding problems, there was no mention of a list in any of the radio communication or intercepted transmissions between 1900 and 2200. Therefore, the Safety Board believes that between 1900 and 2200 either there was no list or that the list was about 5° or less, such as the list that the crew had experienced on February 6 and had not reported.

The underwater survey in July and August 1982 revealed that both the port and starboard manual gate valves at the sea chest were closed and that the crew had inserted the actuating rods into the solenoid valves in the control console to operate the solenoids manually. It could not be determined when these events occurred; however, they suggest that the crew was trying to prevent flooding of the lower hulls by closing the normally open gate valves and that there was a problem with the electrical control system which necessitated the use of the manual rods. Assuming a compression factor of 3 to 1 for air at the 100-foot depth of water, the Safety Board calculated the amount of water in each lower hull tank and compartment at atmospheric pressure as found during the July 1982 underwater diving survey.

The results in terms of percent full in July 1982 versus February 14, 1982, are presented in tables II and III. The Safety Board does not consider the numbers presented in tables II and III to be totally accurate because of the difficulty of obtaining the soundings of the tanks; the uncertainty of the exact distribution of ballast water, drill water, and fuel oil level on February 14; and the assumptions used in converting the volume of trapped air at 100 feet of water to atmospheric conditions. However, the results indicated a significant increase in draft, a port bow list, and a shifting of ballast water forward. The addition of 5,239 long tons would have increased the OCEAN RANGER's draft from 80 to 110 feet. The greater increase in ballast water in the forward tanks and in the portside tanks would have resulted in a port bow list. At least one aft tank, PT-10, which was normally kept full, was nearly empty and forward tanks PT-4, PT-5, ST-4, and ST-5, which contained low liquid levels on the evening of February 14, had significantly greater amounts of water in July 1982. Since the lower hull tanks and compartments were found structurally intact, the amount of trapped air should have remained constant from February 15 to July 1982. Water may have entered the tanks and compartments through the vent openings on the upper deck as the OCEAN RANGER capsized, but with the manual gate valves closed and the MODU upside down, the air would have remained trapped in the tanks and compartments.

Table II.--Lower port hull.

Ballast Tank	(Percent Full 27/ February 14, 1982) Based on Recovered Documents	Percent Full 27/ July 1982 Based on Diving Survey	Net Loss (-) or Gain (+) (long Tons)
PT-1	1	100	+507
PT-2	68	100	+307
PT-3	100	100	0
PT-4	5	100	+776
PT-5 (drill water)	10	72	+494
PT-6 (fuel oil)	16	45	+194
PT-7	2	46	+354
PT-8	100	91	-66
PT-9	100	91	-66
PT-10	100	15	-601

27/ All volumes converted to atmospheric pressure.

Table II.--Lower port hull (continued)

Ballast Tank	(Percent Full February 14, 1982) Based on Recovered Documents	Percent Full July 1982 Based on Diving Survey	Net Loss (-) or Gain (+) (long Tons)
PT-11	100	91	-66
PT-12 (fuel oil)	26	96	+469
PT-13 (drill water)	63	81	+139
PT-14	68	91	+191
PT-15	100	100	0
PT-16	100	87	-47
Compartment			
Pumproom	0	44	+217
Propulsion Room	0	12	+78
Total			+2,880

Table III.--Lower starboard hull

Ballast Tank	Percent Full 28/ February 14, 1982 Based on Recovered Documents	Percent Full 28/ July 1982 Based on Diving Survey	Net Loss (-) or Gain (+) (long Tons)
ST-1	1	100	+507
ST-2	100	100	0
ST-3	100	100	0
ST-4	55	97	+345
ST-5 (drill water)	12	50	+307
ST-6 (fuel oil)	4	45	+274
ST-7	2	69	+344
ST-8	100	69	-217
ST-9	100	69	-217
ST-10	100	80	-139
ST-11	100	96	-31
ST-12 (fuel oil)	36	92	+376
ST-13 (drill water)	36	100	+504
ST-14	57	81	+201
ST-15	100	91	-71
ST-16	100	93	-24
Compartment			
Pumproom	0	0	0
Propulsion Room	0	0	0
Total			+2,359

28/ All volumes converted to atmospheric pressure.

The survey results indicated several anomalies. There was an indication of the presence of sea water in both PT-6 and ST-6 forward fuel oil tanks. In desperation, the crew may have attempted to ballast the after fuel oil tanks PT-13 and ST-13, both of which were found almost full, and inadvertently introduced some water into the forward fuel oil tanks. The soundings indicated a significant amount of water in the port pumproom and some water in the port propulsion room; however, based on the available evidence, the Safety Board could not determine the source of the water.

The Safety Board believes that the cause of the 10° to 15° port bow list about 0100 on February 15 was a combination of a ballast control panel malfunction, operational error, and the design limitation of the OCEAN RANGER ballast pumps because they were not able to deballast forward tanks with a forward trim greater than 11°. Between 1900 and 2200 on February 14, one or two portlights broke which resulted in the ballast control panel and other electrical equipment in the control room becoming wet. It is likely that the OCEAN RANGER experienced both a list and an increase in draft during this period. Because the list, if any, was not reported, the Safety Board believes that it was probably less than 5°. The listing incident on February 6, which resulted in a 5° list, was not reported to shoreside personnel for several days. Because of the sea conditions, any increase in draft between 1900 and 2200 would have been difficult to detect using the external draft marks on the corner columns, and it would have taken some time to calculate the change in draft using the tank gauge readings. The radio communications and intercepted transmissions between 2145 and 2200 indicated that the situation aboard the OCEAN RANGER had stabilized but did not indicate necessarily that the OCEAN RANGER had no list or increase in draft.

From 2200 on February 14 to 0052 on February 15, there were no radio transmissions, other than the 2330 weather report or intercepted transmissions from the OCEAN RANGER. If the OCEAN RANGER listed or had a significant increase in draft at 2200, the crew probably attempted to correct the list and draft between 2200 and 0052 by deballasting tanks or counterflooding. Even if there were no listing or increased draft at 2200, the crew may have attempted to deballast the OCEAN RANGER to a 75-foot draft because of the broken portlight(s) or to provide additional clearance between the marine riser and the BOP because of the 20-foot heaves the OCEAN RANGER was experiencing. About 1900 on February 14, the SEDCO 706 was deballasted from 80 to 75 feet after being struck by a large wave and the ZAPATA UGLAND was also deballasted from 80 to 75 feet on February 15 when the crew encountered problems recovering its marine riser. Since the actuating rods were found in many of the valve control solenoids during the July 1982 diving survey, the crew must have attempted to operate the ballast valves manually, sometime before 0130 when they abandoned the OCEAN RANGER, and may have inadvertently flooded empty or partially empty forward tanks, causing the severe list reported at 0052. When the manual gate valves at the sea chests were actually closed could not be determined, but the July 1982 diving survey indicated significant flooding of both port and starboard lower hull tanks which had to have occurred before the gate valves were closed. The crew may not have been as familiar with the manual operation of the solenoid valves in the control consoles as required to overcome the OCEAN RANGER's list problems. An experienced former control room operator, who indoctrinated the senior control room operator aboard the OCEAN RANGER on February 15, testified that he did not know that there was a manual method of solenoid valve control. A former experienced master testified that he knew of the manual system but had never used it. The forward empty tanks could have flooded quickly if the crew had unknowingly left the wrong valves open while attempting to deballast. If the electrical power to the ballast control console had been shut off because of an electrical malfunction, the crew would have had no visual display of the position of the valves. If the inlet valve from the sea chest had been open, the forward tanks could have been flooded at a faster rate than the ballast pumps could have pumped. As the trim angle increased, the pumping rate would have decreased because of the reduced head of water to overcome frictional loses, thus aggravating any flooding. Some ballast water also could have gravitated from the after tanks to the forward tanks through any valves that were not closed and increased the list.

Once a 10° to 15° list developed, only limited possibilities were available to the crew to correct the list quickly. With the OCEAN RANGER operating at its maximum designed draft of 80 feet and its pumprooms and propulsion rooms located aft, there was limited available ballast space aft for counterflooding. When the list angle exceeded about 11°, the OCEAN RANGER's pumps would have been unable to dewater forward ballast tanks PT-2 and PT-3 and the pumping rate for the ballast tanks further aft would have been lowered because of the reduced head of water. Although it may have been possible to correct the 10° to 15° list, using the ballast pumps alone, it would have taken a considerable amount of time because of the limitations of the pumps. The only quick method for the crew to have stabilized an increasing list would have been to flood the after fuel oil and drill water tanks. Although the ballast system had limitations, properly trained and knowledgeable personnel should have been able to correct a stabilized 10° to 15° list.

Because the valves closed automatically with the loss of electrical power, the Safety Board does not believe that the additional water, determined to be in the lower hull tanks of the OCEAN RANGER by the July 1982 diving survey, could have been introduced by an electrical malfunction alone unless the crew failed to secure all electrical power to the control console after the malfunction. Furthermore, the Safety Board does not believe that the broken portlight(s) could have caused the ballast pumps to become inoperative since the ballast pumps could have been operated from the pumproom if the controls in the control room had become wet. Because the manual actuating rods were found inserted in the solenoid valves in the ballast control console, the control panel was probably deenergized before the capsizing. The Safety Board believes that the actuating rods may have been inserted before the 0052 distress call and that the severe list reported at 0052 may have been a result of the crew's attempt to deballast, using the manual control method. Since it is probable that no one aboard the OCEAN RANGER had ever used the manual system, it may have taken some time to insert the rods. At the same time the rods were inserted, the crew probably shut the manual sea chest valves to prevent any further flooding. At 0105, someone in the OCEAN RANGER's control room reported a port list and all countermeasures ineffective. As the list increased beyond 10° to 15,° the port chain locker would have begun flooding, further increasing the list. Since the crew could no longer control the list, they abandoned the OCEAN RANGER.

Stability

The OCEAN RANGER was moored on a heading of 311° on February 14 and 15. From 1730 to 2330 on February 14, the wind direction veered from 220° to 270° with a maximum reported sustained wind speed of 72 knots at 1730 and 2030. Intact stability calculations performed after the accident indicated that, with a sustained wind speed of 72 knots, the OCEAN RANGER would have experienced a starboard quarter list of about 15° if unrestrained by the mooring system, and a 4° list considering the restraining effect of the mooring systems. Since there is no indication of any problems with the mooring system before capsize, the Safety Board believes the mooring system was effective in limiting the OCEAN RANGER's list because of the wind to about 4°.

Because of the friction of the earth and seas, wind speed decreases near the surface of the earth. Since the anemometer on the OCEAN RANGER was located about 284 feet above mean sea level, the maximum sustained wind speed at the OCEAN RANGER's upper hull level would have been only about 63 knots and the actual maximum starboard quarter list would have been about 3°. The approximate maximum sustained wind speed at the OCEAN RANGER's upper hull level at 2330 on February 14 probably was about 51 knots, based on an anemometer reading of 58 knots.

Since the crew of the OCEAN RANGER reported a port bow list of about 10° to 15° about 0100 on February 15, the wind listing moment was actually tending to bring the OCEAN RANGER to an upright condition. The OCEAN RANGER may have experienced about a 1° increase in any port bow list because the sustained winds decreased from 63 to 51 knots between 2030 and 2330 on February 14. The intact stability calculations indicated that the OCEAN RANGER had sufficient intact stability to withstand the weather conditions it experienced that night provided there were no other listing forces acting on the MODU.

USCG and ABS stability standards applicable to the OCEAN RANGER require that a MODU be able to withstand the flooding of compartments extending within 5 feet of its operating draft. The 1979 IMCO MODU Code has similar requirements. These standards required that the OCEAN RANGER withstand the flooding of compartments within one of its columns near its 80-foot waterline. The OCEAN RANGER was designed with horizontal watertight bulkheads within each column to limit the amount of flooding in case of damage to a column. The USCG, the ABS, and the IMO do not have any standards for flooding of lower hull tanks or compartments on semisubmersible MODU's. Calculations performed after the accident indicated that the flooding of empty or partially empty forward ballast tanks on the OCEAN RANGER at its operating draft of 80 feet could have produced angles of list exceeding its downflooding angle. 29/ The lower hull compartments on MODU's, such as the OCEAN RANGER, can flood in several ways: (1) a piping failure could flood the pumproom; (2) a small structural failure could flood any tank or compartment; or (3) operational errors or electrical malfunctions could result in the flooding of empty tanks. Because the evidence indicated that the lower hull tanks can flood quickly and cause a significant list, the Safety Board believes that the USCG, the ABS, and the IMO should revise their stability standards for MODU's similiar to the OCEAN RANGER to require that MODU's be capable of surviving the flooding of lower hull compartments at their normal operating draft. The revised standard also should include a requirement that there be a capability to dewater lower hull compartments at all angles of list after the assumed flooding.

In recognizing the need for a higher level of protection against flooding than required by USCG and ABS standards, ODECO designed the OCEAN RANGER to withstand the flooding of one chain locker or certain individual compartments in the lower hull at the 80-foot operating draft. In addition, the OCEAN RANGER's operating manual suggests that the master maintain the lower hull forward and after tanks full and the center tanks empty. This ballast configuration would, in effect, limit the list angle in case of accidental flooding. However, it was the practice of the masters and control room operators aboard the OCEAN RANGER to maintain the lower hull center ballast tanks full and to have some lower hull forward ballast tanks empty to minimize the amount of water pumped to alter trim. The Safety Board determined that on February 14,

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29/ Downflooding angle is the static list angle at which flooding of internal compartments within a vessel will first begin. It is assumed that once internal compartments begin to flood, other compartments will progressively flood and the vessel will eventually capsize and sink.

center tanks PT-8, ST-8, PT-9, ST-9, PT-10, ST-10, PT-11, and ST-11 were full while forward tanks PT-4, PT-7, and ST-7 were empty, and ST-4 was 55 percent full. The OCEAN RANGER's design and its operating manual did not consider the accidental flooding of empty lower hull forward ballast tanks. The operating manual does not address any maximum trim angle beyond which the ballast pumps could not be used to deballast the forward tanks or any precautions to be taken to prevent flooding of a chain locker by wave action through the chain pipe and wire rope trunk openings. The 25-square-foot wire rope trunk openings are not shown on the damage control drawing in the operating manual.

If the ballast distribution on February 14 and 15 had been closer to that recommended in the OCEAN RANGER's operating manual (i.e., center ballast tanks empty, forward ballast tanks full), the amount of trim resulting from flooding would have been greatly reduced, thus, preventing flooding of the chain lockers and keeping the trim within the range of the ballast pumps which may have prevented the loss of the OCEAN RANGER. However, the OCEAN RANGER was not required by USCG or ABS to survive the flooding of empty or partially empty lower hull tanks at the 80-foot operating draft. The Safety Board believes that ODECO should review and revise all its operating manuals to provide information to the crew of semisubmersible MODU's concerning list angles caused by the accidental flooding of empty lower hull tanks, guidance to prevent the flooding of chain lockers (including wire rope trunk openings) due to wave action and information on the limitations of the ballast pumps due to trim angle. Also, ODECO should incorporate in its designs a permanent pumping system for dewatering the chain lockers in case of flooding.

The 1930 February 14 NORDCO, Ltd., weather forecast for the OCEAN RANGER, which was valid from 2030 on February 14 to 0230 on February 15, predicted winds of 270° at 75 knots with gusts to 90 knots, a significant sea wave height of 25 feet, with a maximum sea wave height of 44 feet. The average winds that affected the OCEAN RANGER (at the height of the anemometer) during that time were about 250° at 65 knots with gusts of 78 knots. The average significant sea wave height and average maximum sea wave height during that time were about 34 feet and 52 feet, respectively. The NORDCO, Ltd., forecast was substantially correct and provided the crew of the OCEAN RANGER adequate guidance concerning the severity of the storm. It was a particularly severe winter storm with hurricane force winds. During its entire operating history, the OCEAN RANGER had experienced only six storms approaching the intensity of the storm on February 14 and 15, 1982, but considering the combination of wind and waves, this was probably the most severe storm it had ever experienced.

The OCEAN RANGER's operating manual stated that, under certain conditions, the MODU could experience a permanent list or trim in a seaway. This information was based on a SNAME study in regular waves. Since the OCEAN RANGER was subjected to a random sea state on February 15, the Safety Board does not believe that it experienced any wave induced heel or trim angle. ODECO may have misinterpreted the results of the SNAME study since under real sea conditions this phenomenon may produce large-amplified, long-period rolling oscillating and not a steady heel or trim. Therefore, ODECO should revise its operating manuals for semisubmersible units to accurately reflect the problem a unit may encounter as the result of low GM and large, steep waves.

Survival Systems

The Safety Board considered a number of factors which may have contributed to the large loss of life: (1) the OCEAN RANGER was operating in 31° F water and the crew was not provided with exposure suits for protection against the cold temperatures which cause hypothermia; (2) the OCEAN RANGER did not have USCG approved lifesaving equipment; (3) the severe weather conditions made launching of the lifeboats difficult; and (4) the standby boat was not provided with adequate equipment for recovering persons from the water.

In the 31° F water and with the air temperature at 24° F, the survival time of a person in the water without thermal protection was less than 15 to 45 minutes depending on the individual's physical condition. Several experimental studies 30/ have shown that the use of exposure suits which provide proper thermal protection can extend an individual's survival time in cold water by several hours. Title 46 CFR 94.41 currently requires each vessel operating on the Great Lakes to carry an exposure suit which provides thermal protection for each person on board.

On September 22, 1978, the Safety Board recommended that the USCG:

> Require that exposure suits be provided for each crewmember on vessels that routinely operate in areas of cold air or sea temperatures. (M-78-65)

On May 19, 1980, the USCG responded as follows:

> The Coast Guard concurs with this recommendation. The Coast Guard does not intend to require oceangoing vessels with enclosed lifeboats to have exposure suits. The best opportunity for survival is provided by keeping the survivors out of the water and dry. Even the best exposure suits cannot compare with the potential for survival provided by enclosed boats. Improvements in the launching systems for these boats significantly increase the probability that they will be successfully launched. It, therefore, appears to be an unnecessary additional cost burden on the operator to require exposure suits in addition to enclosed lifeboats for 200% of the persons on board and float-free liferafts for 100% of the persons on board. It is not expected that the exposure suits will be needed. The situation on the Great Lakes is somewhat different. Because of the nature of the Lakes, rescue in never far away. We will be requiring lifeboats for only 100% of the persons on board. In a final rule which is expected to be published in the next weeks (CGD 76—033a), the Coast Guard will require exposure suits on Great Lakes vessels. The exposure suits can provide a reasonable measure of "back-up" capacity since it is probable that survivors would be picked up quickly.
>
> With regard to the U.S. proposal in IMCO, it is expected that two more meetings of the Lifesaving Appliances Sub-Committee after 1979 will be required before a firm position to be [sic] confirmed by IMCO's Maritime Safety Committee and the IMCO Assembly. Since the Lifesaving Appliances Sub-Committee will probably meet once a year in the future, the Coast Guard should be able to begin a rulemaking project at the end of 1981, without waiting for IMCO to complete the formal approvals. A final rule could then be in effect by mid-1983 which should roughly correspond to the time of the final IMCO action.

30/ Harnett, R.M., O'Brien, E.M., Sias, F.R. and J.R. Pruitt (1979) "Experimental Evaluations of Selected Immersion Hypothermia Protection Equipment," U.S. Coast Guard Report No. CG-D-79-79, October 12, 1979. Hayward J.S., Lisson, P.A., Collis, M.L. and J. D. Eckerson (1978) "Survival Suits for Accidental Immersion in Cold Water: Design-Concepts and their Protection Performance," University of Victoria, January 1978.

The Safety Board believes that some of the persons aboard the OCEAN RANGER may have been saved if they had been wearing exposure suits similar to those required on Great Lakes vessels. Even though the OCEAN RANGER was equipped with enclosed lifeboats for 158 persons and liferafts for 200 persons and the SEAFORTH HIGHLANDER arrived in the area within 1 hour of the OCEAN RANGER's initial call for assistance, no one was saved. The OCEAN RANGER's lifeboats provided some exposure protection, but many persons aboard the drilling rig entered the water before the rescue boats arrived while others entered the water when the lifeboat capsized as they attempted to board the SEAFORTH HIGHLANDER. Had the persons aboard the OCEAN RANGER been wearing exposure suits, their survival time would have been extended by several hours and they could have assisted in their own rescue, increasing their chances for survival.

Most of the primary lifesaving equipment on the OCEAN RANGER was not USCG approved. The No. 1 and No. 2 Harding lifeboats were similar in design to USCG-approved lifeboats but the offload type releasing gear required the No. 1 and No. 2 lifeboats to be fully waterborne before they could be released. USCG-approved designs require an onload type releasing gear which permits the boat to be released from the falls while still under load. Under the severe sea conditions that existed on February 15, the No. 2 (Harding) lifeboat could have smashed against the OCEAN RANGER's columns or braces while the boat was being lowered or before it could be released from the falls which would account for the hole reported in the bow of the lifeboat. In the ALEXANDER L. KIELLAND accident, three of its seven lifeboats were smashed against the rig's columns because the lifeboats were equipped with offload type releasing gear requiring them to be fully waterborne before they could be released.

The hole in the bow of the No. 2 lifeboat allowed sea water to enter, which contributed to the hypothermia that the persons aboard the boat must have suffered because of prolonged exposure to the cold air, and also reduced the lifeboat's stability. The lifeboat was designed to be stable and selfrighting only if the hull remained intact and the occupants remained seated with their seatbelts fastened. With the free surface effect of the water in the boat and four to six persons standing on the portside outside the canopy, the lifeboat probably did not have sufficient stability to remain upright or to right itself after capsizing. With hatches open and a hole in the hull, the capsized boat would have quickly filled with water, drowning those persons strapped in the seats and immersing the rest in the frigid water. Proposals by the USCG both here in the U.S. and at IMO to improve the selfrighting capabilities of enclosed lifeboats by increasing the amount of foam flotation to expose the hatches on one side would not correct the problem of open hatches. If an enclosed lifeboat's hatches are left open, flooding water may prevent the lifeboat from selfrighting. However, the USCG proposals would provide for escape if an enclosed lifeboat does not selfright.

Both the No. 3 and No. 4 lifeboats and davits were of a USCG-approved design, but their installation had not been inspected by the USCG. When the Certificate of Inspection was issued in December 1979, ODECO was given 2 years to complete the installation; however, at the time of the accident, the No. 3 lifeboat still had not been installed and the installation of No. 4 lifeboat had not been approved by the USCG.

USCG regulations required davit-launched liferafts on board the OCEAN RANGER. The liferafts on the OCEAN RANGER, although USCG-approved were not davit-launched nor had they been serviced by a USCG-approved facility. The servicing facility used for the OCEAN RANGER liferafts may not have had the necessary repair parts, manuals, servicing bulletins, and packing instructions since it had not been approved to service the type of liferafts used aboard the OCEAN RANGER facility. Therefore, ODECO should establish procedures that require USCG-approved liferafts on its U.S flag MODU's be serviced only at USCG-approved facilities as required by 46 CFR 160.051-6. When the results of the Canadian laboratory tests on the recovered liferafts are completed, the USCG should undertake a review of its liferaft specifications to determine if the specifications need revision.

Of the 21 Billy Pugh Model 200 life preservers recovered, 10 were from lot 1A which did not meet USCG standards but had been approved without authorization by a local USCG Marine Safety Office before the Commandant of the USCG had approved the design. Tests indicated that lot 1A life preservers had a tendency to slip off over the wearer's head while jumping into the water. The Safety Board could not determine if this deficiency contributed to the loss of life, but it believes that the USCG should examine and modify its approval procedures so that lifesaving equipment is not marked to indicate USCG approval when, in fact, the design had not been approved.

Launching a lifeboat in a normal sea condition even from relatively small heights can be difficult. Launching a lifeboat from a height of about 70 feet above the water from the upper deck of a semisubmersible, such as the OCEAN RANGER, into 30-foot seas with 70-knot winds involves great hazards. Both the OCEAN RANGER and the ALEXANDER L. KIELLAND accidents are examples of the difficulty involved in abandoning semisubmersible drilling units and similar structures under severe sea conditions, using existing lifesaving equipment. The Norwegian Maritime Directorate and several other Nordic authorities have long recognized this problem and, as a result of their studies, have developed the free fall launching system which effectively eliminates on-load versus off-load limitations used in conventional systems. The USCG and the U.S. offshore oil industry should thoroughly examine current lifesaving systems and improve the design of such systems. The USCG also should evaluate the use of free fall launching systems on U.S. vessels.

Canadian government regulations require a standby vessel to be assigned to each drilling rig at all times as a vital part of the survival system of MODU's. Norway and the United Kingdom also have similar requirements. Standby boats are unable to remain close to their rigs in heavy weather because of the danger of drifting into the anchor cables or anchor buoys, which in the case of the OCEAN RANGER, were about 1 mile in scope. Due to the severe weather conditions during the night of February 14 and 15, the SEAFORTH HIGHLANDER, the BOLTENTOR, and the NORDERTOR ran upwind for several miles, turned, and then proceeded slowly downwind of their respective rigs for several miles before turning upwind again. At the time of the distress call, both the BOLTENTOR and the NORDERTOR were within 2 miles of their rigs but the SEAFORTH HIGHLANDER was 7 miles away from the OCEAN RANGER but was on scene within 1 hour after the first distress message was sent. The first Canadian Forces rescue helicopter, which was located about 125 nmi from St. John's, did not arrive in the area until over 8 hours later, after refueling in St. John's. The SEAFORTH HIGHLANDER, the BOLTENTOR, the NORDERTOR, the Mobil contracted helicopters, and the Canadian Forces Search and Rescue aircraft, in spite of severe wind and sea conditions, made every effort to save the crew of the OCEAN RANGER. Wind speeds were above 45 knots, the normal maximum takeoff velocity, when the MOBIL helicopters took off from St. John's about 0330 on February 15. Throughout the day on February 15 and the next day, rough sea conditions continued as vessels and aircraft searched for survivors.

MODU's, such as the OCEAN RANGER, require frequent replenishment of fuel, stores, and drilling materials while drilling. Supply boats provide this support in addition to periodically serving as standby vessels. Although the SEAFORTH HIGHLANDER was rigged for towing and setting anchors, it was not adequately equipped to recover persons from the sea in the storm conditions that existed during the night of February 14 and 15,

1982. Use of equipment, such as liferings, nets, and liferafts, that was aboard the SEAFORTH HIGHLANDER required the crewmembers of the standby boat to expose themselves to extremely hazardous conditions on open decks to effect any rescue and required participation by those being rescued if any attempt was to be successful. The testimony of the crewmembers of the SEAFORTH HIGHLANDER, in describing the events following the capsizing of the OCEAN RANGER's lifeboat, clearly showed that the effects of hypothermia quickly rendered the OCEAN RANGER's crewmembers helpless in the cold water. Several European marine equipment suppliers have developed rescue baskets that do not require the survivors to touch the hull of the rescue vessel and involves little or no participation by those being rescued. If the SEAFORTH HIGHLANDER had been equipped with such a device when its crewmembers attempted to recover the survivors from the OCEAN RANGER, some lives possibly could have been saved.

Standby vessels also provide an emergency platform that can evacuate a large number of persons quickly in the event of a fire, a well blowout, or similar situation in addition to their primary role in the recovery of persons that accidentally fall overboard. Since standby boats are already an integral part of the drilling operations of a MODU, the Safety Board believes that the USCG should require that a suitable vessel, properly equipped for ocean rescue, be assigned to all U.S. flag MODU's when moored over a drill site. Both the OCEAN RANGER and the ALEXANDER L. KIELLAND accidents point out the need for quick response capability, especially in areas of cold weather. When engaged in such rescue operations, the crews of standby boats also should have adequate thermal protection against the cold. The crews of standby vessels should be provided with thermal protection designed for rescue operations so that they can perform their rescue functions in cold water more effectively.

After the OCEAN RANGER radioed it first distress message, the MOBIL helicopters were the first aircraft to respond. Two of these helicopters, flying in the severe weather conditions that existed during the early morning hours of the accident, observed the lifeboats, liferafts, and persons in the water but could do nothing to recover them other than direct the standby boats to the area. These helicopters were not designed for water rescue operations, but only to transport personnel and limited amounts of equipment. An example of the limitations of this type of helicopter was also evident during the rescue operations in the Potomac River in Washington, D.C., on January 13, 1982, following the crash of an airplane soon after takeoff from Washington National Airport. 31/ Makeshift rescue aids were dropped from the helicopter as the pilot hovered over survivors in the cold water. The numbing cold affected the ability of those persons in the water to hold on to liferings dropped from the helicopter in the rescue operations. Standby boats provide the more reliable method of recovering persons from the water in offshore operations.

ODECO and MOBIL each had an emergency procedures manual for the OCEAN RANGER. ODECO's manual contained information to be followed by the toolpusher for the various types of emergencies that could occur aboard the drill rig, recognizing that each situation required a separate evaluation according to the prevailing conditions. The manual stated that, if a storm was forecast with winds of 100 mph or more (87 knots), evacuation of the rig should be considered. Although the toolpusher is described as having the responsibility for any decision to abandon the rig, the manual lists various steps he should follow to enable him to reach a decision -- contacting the shore based manager (MOBIL Superintendent), requesting additional weather information, reviewing the past

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32/ Aircraft Accident Report--"Air Florida, Inc., Boeing 737-222, N62AF, Collision with 14th Street Bridge, Near Washington National Airport, Washington, D.C., January 13, 1982," (NTSB-AAR-82-8.)

wind and sea conditions to see if they are increasing or decreasing. The manual also says that he and the shore manager should consult to devise evacuation if necessary. The NORDCO, Ltd., weather forecast predicted 75-knot (86 mph) winds, gusting to 90 knots (104 mph) which was above the suggested evacuation level. The maximum wind gust recorded on the OCEAN RANGER (at the height of the anemometer) was 98 knots (101 mph) at 1630 on February 14. However, at 2330, the wind had decreased to 58 knots (67 mph). The OCEAN RANGER's toolpusher hungoff the drill string and disconnected the marine riser in accordance with the ODECO emergency procedures manual. However, the toolpusher did not discuss evacuation with the MOBIL superintendent in St. John's.

Under the terms of the drilling agreement, it was MOBIL's responsibility to provide transportation if evacuation was contemplated. However, the only statement in MOBIL's emergency procedures manual relating to heavy weather emergencies was that the MOBIL superintendent should consult with the toolpusher about the appropriate plan of action. In the other types of emergencies outlined in the MOBIL emergency procedures manual, the steps to be taken were rather well defined; however, in the area of transportation, where both standby boats and helicopter service play a very important role, there were little or no written procedures to follow. The Safety Board believes that MOBIL's emergency procedures were not adequate for heavy weather emergencies affecting the OCEAN RANGER and that MOBIL's emergency procedures manual for MODU's operating off the coast of Newfoundland should be modified to include a detailed disaster plan for heavy weather similar to those prepared for other types of emergencies. Included in this plan should be a description of the duties of the person-in-charge, in amplification of his already established responsibility, together with the duties of the MOBIL superintendent, the MOBIL radio operator, the standby boats, helicopters, and other MOBIL resources.

<u>U.S. Coast Guard Inspections.</u>

Biennial inspections of U.S. mobile offshore drilling units operating off the coast of foreign countries present a logistical problem to the USCG. At times, MODU's operate in remote areas many miles offshore; therefore, it is necessary that owners of MODU's notify the USCG in advance when a MODU is ready for its biennial inspection. Title 46 CFR 107.215(b) states that the request may be made at least 60 days before the expiration date appearing on the unit's last Certificate of Inspection.

The USCG did not receive ODECO's request for a biennial inspection of the OCEAN RANGER until January 26, 1982, 1 month after its Certificate of Inspection had expired. After the request was made, the USCG and ODECO arranged for two USCG inspectors from the Providence, Rhode Island, Marine Safety Office to inspect the OCEAN RANGER while on site off the coast of Newfoundland on February 16. The ODECO Operations Manager in St. John's stated that the request for inspection was late because completion of the installation of the lifeboat davits and USCG-approved lifeboats had been delayed by bad weather.

The Safety Board believes that ODECO did not act prudently. The USCG permitted ODECO 2 years to replace the Harding lifeboats with USCG-approved lifeboats, or to obtain USCG approval of the Harding lifeboats and to provide davit-launched liferafts, or to use U.S. approved lifeboats as a substitute for the davit-launched liferafts. The Harding lifeboat's releasing gear was not approved but it was not addressed by the USCG. As a result of the failure of ODECO to comply with any of these options, the OCEAN RANGER was not equipped with USCG-approved lifeboat installations or davit-launched liferafts at the time of the accident. The Safety Board could not determine if this failure to comply with USCG requirements contributed to the loss of life on the OCEAN

RANGER; however, the lack of compliance decreased the usable lifeboat and liferaft capacity. Under the existing wind and wave conditions, most of the nondavit-launched liferafts probably blew away before the persons in the water could board them. The three operational lifeboats (Nos. 1, 2, and 4) were in davits ready for use. The fourth lifeboat (No. 3) was lashed to the upper deck awaiting installation. Examination of the forward port Harding lifeboat (No. 1) after the accident revealed that the lifeboat had never been launched. It probably was inaccessible since the OCEAN RANGER had listed to the port bow and the wind and waves were coming from that direction. As a result, only the 50-person Harding lifeboat (No. 2) and the 58-person Watercraft lifeboat (No. 4) located on the stern were available for the 84 persons aboard. The two lifeboats should have provided sufficient capacity for evacuating all persons aboard; however, there is no evidence that the No. 4 Watercraft lifeboat on the stern was ever launched.

The OCEAN RANGER had been initially inspected by the USCG in December 1979 and was required to have a biennial inspection before December 27, 1981. The USCG was scheduled to reinspect the drilling unit between October 1980 and February 1981. The biennial inspection was required by law and regulation while the reinspection was a self-imposed USCG requirement. Even though ODECO was responsible for requesting the USCG to conduct a biennial inspection of the OCEAN RANGER, the USCG also had some responsibility, especially since the USCG normally did not reinspect MODU's in international service. Title 46 USC 391 requires that the USCG biennially inspect a certificated vessel to determine that the vessel can be operated safely. The Safety Board believes the USCG should have the capability within its Marine Safety Information System to determine which vessels are due for their biennial inspection and to notify their owners accordingly. Since most vessel owners comply with the biennial inspection requirements, notification should not be a burden to the USCG. If the USCG had notified ODECO early in December that the Certificate of Inspection for the OCEAN RANGER was due to expire and that it had no record that the outstanding requirements had been satisfied, ODECO may have had the USCG-approved lifeboats installed and inspected before the February 15, 1982, accident.

The USCG's policy on the reinspection of MODU's has not been consistent, although regulations which became effective on December 4, 1978, stated that the USCG would regularly reinspect MODU's. The OCEAN RANGER was not reinspected between October 1980 and February 1981 as required by USCG policy because of budgetary constraints. On January 7, 1982, the USCG suspended reinspections of MODU's worldwide. On April 6, 1982, the USCG resumed reinspecting MODU's on the U.S. outer continental shelf, but it has not resumed reinspecting MODU's in international service, such as the OCEAN RANGER. The Safety Board believes that the USCG's failure to reinspect the OCEAN RANGER did not contribute to this accident since the informal inspection by a USCG marine inspector during October 1981 found the MODU in satisfactory condition. However, the Safety Board considers reinspections of U.S. MODU's in international service just as important as reinspections of MODU's on the U.S. outer continental shelf. Therefore, reinspection of all U.S. MODU's should be reinstituted by the USCG, regardless of their location.

There is a need for ODECO to improve its compliance with U.S. inspection laws and regulations. One of the options offered by the USCG to deal with the lack of USCG-approved lifeboats in 1979 should have been accomplished on the OCEAN RANGER before the 1981-1982 winter season when severe storms and cold weather off the coast of Newfoundland can make working conditions most difficult and cause delays in the installation of any exposed equipment. ODECO should establish a policy of applying to the USCG for a renewal well in advance of the expiration date of a MODU's USCG Certificate of Inspection if the MODU is operating in international service.

Crew Qualifications

In 1978, the USCG published regulations for the inspection and certification of mobile offshore drilling units. However, it has not included personnel qualifications or manning standards for MODU's in the regulations, except to specify the number and qualifications of lifeboatmen required to man primary lifesaving equipment and to require that the owner must designate an individual to be the master or person-in-charge of a MODU. As a result of its investigation of the capsizing and sinking of the self-elevating MODU OCEAN EXPRESS, the Safety Board recommended on April 17, 1979, that the USCG:

> Expedite the promulgation of regulations for personnel qualifications and manning standards for self-elevating mobil offshore drilling units, and require that industrial personnel who perform seafaring duties obtain appropriate training and licenses. (Class II, Priority Action) (M-79-43)

On June 4, 1980, the USCG responded as follows:

> The Coast Guard partially concurs with the recommendation. Manning and crew qualification standards are being applied to MODU's of the "bottom bearing" non-self-propelled type (such as the OCEAN EXPRESS) as these units come under the inspection process under 46 CFR 1-A in the next several years. Manning standards will apply only when such units are in navigation. At this point it is contemplated that the standard manning for marine personnel, while in navigation, will consist of:
>
> 1 - Designated Person in Charge
> 2 - Able Seaman
> 1 - Ordinary Seaman
> -- Lifeboatman (number appropriate for the installed lifesaving equipment necessary to accommodate the number of persons on board).
>
> Development of requirements for personnel on structures and MODU's not in navigation is being developed under the authority of the OCS Act. The Coast Guard believes that the OCS Act places limitations on the Coast Guard's ability to carry out the intent of this recommendation while the unit is in the bottom bearing mode. The OCS Act is applicable only to those activities on the United States Outer Continental Shelf. Accordingly, the application of a manning scale on units engaged in worldwide operations while in the bottom bearing mode is not possible under the provisions of the OCS Act.

On June 9, 1981, the USCG further replied:

> We have attached an IMCO document entitled "Training Qualifications of Crews Serving on Mobile Offshore Units" (STW XIV/WP.4) dated 21 January 1981 (Enclosure (2)). This document deals with a variety of considerations affecting units such as the OCEAN EXPRESS. Various duties/training qualifications of the person-in-charge and other persons are covered. The working group preparing the document did not stipulate whether the person-in-charge should be drawn from seafarer or regularly assigned special personnel with responsibility for others

(Appendix II, 3 and 4). This recognizes reality in that a mobile unit such as the OCEAN EXPRESS is a complex mixture of both industrial and marine considerations. The Coast Guard is of a similar opinion and believes a person qualified under either category could function in the position. Although this document is currently a working paper, it is scheduled to be formally reviewed at the 15th session of the Subcommittee on Standards of Training and Watchkeeping scheduled for February 1982. Due to the inherent limitations of the OCS Lands Act and the restrictions of the domestic statutes concerning vessel inspection and manning, the international agreement method appears the most viable initial approach. Although the resulting domestic regulations may be somewhat fragmented (due to the diverse statutory authority) and lacking when considering a bottom bearing unit on a foreign assignment, a foreign country which subscribes to the resolution could fill in this gap.

Insofar as the imposition of additional manning regulations specifically for MODU's, this appears to be generally unwarranted. Presently 46 CFR 157.20-15 addresses the Able Seaman/Ordinary Seaman question. The person-in-charge qualifications would be best delayed pending international action. As the STW working paper is almost a direct copy of a position paper presented at the 14th session of the STW in January 1981 by the International Association of Drilling Contractors (IADC), it can be reasonably assumed the industry will initiate compliance. Further, the MODU initial inspection program should be completed during the late summer or early fall of 1981, utilizing the manning scale noted in our letter of 4 June 1980.

The only statement in STW X14/WP.4 concerning personnel qualifications and manning standards, other than emergency procedures and onboard training for group survival states:

3. RESPONSIBILITIES OF PERSON IN CHARGE CONCERNING MARITIME SAFETY TRAINING

3.1 The person in charge should be well acquainted with the characteristics, capabilities and limitations of the unit. This person should be fully cognizant of his responsibilities for emergency organization and action, for conducting emergency drills and training, and for keeping records of such drills.

3.2 The person in charge, or persons delegated by him, should possess the capability to operate and maintain on board the unit all fire-fighting equipment and life-saving appliances and be able to train others in these activities.

The Safety Board believes that personnel qualifications and manning standards for U.S. MODU's are long overdue and that the USCG should act immediately to set such standards. The person-in-charge or the master of a MODU should be licensed and qualified in mobile offshore drilling operations and should have knowledge of USCG regulations, stability characteristics of MODU's, the operation of semisubmersible ballast systems, and lifesaving equipment. If there is no licensed engineer aboard, the person-in-charge or the master also should have knowledge of the unit's standard shipboard systems, other than the industrial machinery. Since the person-in-charge on the OCEAN RANGER was an unlicensed, undocumented individual, the USCG did not have any method of determining his qualifications. Although the USCG regulations address the responsibilities of the person-in-charge, the USCG cannot enforce the rules without jurisdiction over the individual. A former person-in-charge (toolpusher) on the OCEAN RANGER testified that he could not recall ever reading the applicable USCG regulations and, furthermore, was unaware of his responsibilities and obligations under the regulations. The Safety Board believes that a better method to insure compliance with safety regulations is to require that the person-in-charge (normally, the toolpusher) be licensed by the USCG and be fully qualified in all aspects of MODU operation.

Having an unlimited master's license does not necessarily assure knowledge of MODU's. The prospective person-in-charge or master of a MODU, in addition to being licensed, should be examined by the USCG to determine his qualifications in mobile offshore drilling operations which would include knowledge of stability characteristics of MODU's, the operation of ballast systems on MODU's, and any lifesaving equipment peculiar to MODU's. The license of the person-in-charge or the master then should be suitably endorsed.

The OCEAN RANGER's Certificate of Inspection did not require any licensed or documented engineers while the MODU was moored. However, even in the drilling mode, the OCEAN RANGER had machinery related to standard shipboard systems -- electrical power, bilge, ballast, firefighting, and sanitary requirements -- in operation. The Safety Board believes that a licensed engineer should be required by the Certificate of Inspection and be qualified to operate and maintain vital machinery systems.

There is also a need for ODECO to prescribe the duties and responsibilities of the person-in-charge and the master. In its investigation, the Safety Board did not discover any ODECO documents which set forth the duties and responsibilities of the master, the person-in-charge, or the control room operator. Testimony from former and alternate persons-in-charge (toolpushers), masters, and control room operators indicated that they did not have a clear understanding of their duties and responsibilities when moored. The only statement of responsibility which appears in the OCEAN RANGER's operating manual designates the master as having responsibility for the stability of the rig at all times. Whether the master or the person-in-charge was responsible for safety equipment and drills was not clearly defined in the manual. The February 6, 1982, listing incident on the OCEAN RANGER involved a master, who was more than qualified under present manning standards because of his unlimited master's license, but who did not have sufficient knowledge of the OCEAN RANGER to operate the ballast system, a vital element in the safety of a drilling unit. As stated in the ODECO operations manual, the master was responsible for the stability of the OCEAN RANGER; however, when a new master reported aboard, insufficient time was allowed for him to be indoctrinated by the master he was relieving. A senior ODECO official testified that a licensed master would, by reason of his experience and background, be able to study the operations manual and then be able to ballast the rig himself. He also stated that there was sufficient staff aboard the drilling rig to assist the master in learning the ballast system. The Safety Board believes that ODECO did not provide a proper indoctrination period for the master when he joined the OCEAN RANGER on January 26, 1982, since he was not able to operate the ballast control system properly on February 6, 1982.

Under the provisions of the OCEAN RANGER's Certificate of Inspection, certain members of the crew could have "industrial licenses"; however, the qualifications for "industrial licenses" are not contained in USCG regulations. The Safety Board believes that, before the USCG issues "industrial licenses" merely to qualify persons to satisfy the Certificate of Inspection, the necessary qualifications should be defined. The OCEAN RANGER toolpusher was the designated person-in-charge of the drilling unit and was assigned command of one of the lifeboats even though he was not a certificated lifeboatman. It is a proper assignment for the toolpusher (person-in-charge) of a drilling rig to be in command of a lifeboat in the event of the need to abandon ship; however, to be effective, lifesaving equipment should be operated by persons trained in the use of such equipment.

Although the industrial relations representative's duties on the OCEAN RANGER included maintaining all firefighting and lifesaving equipment to USCG standards and conducting drills of all types, which included fire and abandon ship drills, he was not required to be a certificated lifeboatman under ODECO's standards or possess any USCG licenses or documents. It takes both skill and experience to launch a lifeboat safely in adverse weather conditions. Designation of an individual as being in charge of a lifeboat does not automatically qualify him as a lifeboatman.

The Safety Board could not determine whether three of the four certificated lifeboatmen, other than the master, who were required by the OCEAN RANGER's Certificate of Inspection, were aboard at the time of the accident because documented crewmembers were not identified on the station bill. The licensed master was a lifeboatman by virtue of his license. The two ordinary seamen that were determined to be aboard by USCG records normally were not qualified to have been certificated lifeboatmen. It could not be determined from ODECO's personnel records if the required able seamen, who would have qualified as lifeboatmen, were aboard; the partial crew rotation twice weekly resulted in a constant change in individuals. To ascertain if the requirements of the Certificate of Inspection are fulfilled, those documented crew members should be so identified. The Safety Board believes that the station bill on MODU's should identify by name the certificated lifeboatmen assigned to each lifeboat. With the large number of non-marine persons on board MODU's when drilling, the importance of the certificated lifeboatmen becomes even greater than on other types of ocean-going vessels where most of the crewmembers are experienced mariners. The Safety Board believes that, just because the OCEAN RANGER was moored at the drilling site, there was no less of a need for certificated lifeboatmen for the liferafts. As shown by this accident and the ALEXANDER L. KIELLAND accident, the need for properly operated survival equipment is just as great when the MODU is moored as when it is underway. Therefore, the Safety Board believes that the number of certificated lifeboatmen required by a Certificate of Inspection should be based on the number of persons aboard a MODU, rather than the mode of operation.

The investigation revealed that generally ballast control room operators have little or no background in ship stability or other marine related subjects and are recruited from the ranks of those persons working on the drill floor, usually starting at the roustabout level. Training for some prospective control room operators consists of training sessions conducted by the senior control room operator during a portion of a routine workday. Although it operates a stability school in New Orleans to which some control room operators are sent, ODECO does not have any minimum training standards that apply to prospective control room operators.

Ballast control room operators on self-propelled MODU's, such as the OCEAN RANGER, and nonself-propelled MODU's monitor the weight changes of such consumable items as fuel, drill water, cement, barite, drill pipe, casing, and other material, and daily calculate and compare the MODU's vertical center of gravity to the required value. To satisfy drilling requirements, they also maintain the MODU as near as possible to even keel, except for small amounts of list in any given direction, and maintain a 24-hour watch in the ballast control room. Because these functions are vital to the safety of the MODU as a vessel, they should be performed by trained persons who are either licensed or certificated by the USCG. Ballast control room operators should be required to have a working knowledge of the stability characteristics of MODU's and should be capable of operating the ballast control system. ODECO should prescribe the duties and responsibilities of ballast control room operators on its drilling rigs so that minimum training requirements can be established for those persons who are to become control room operators. Each prospective operator should be required to attend ODECO's stability school in New Orleans (or a similar school) before assuming the duties of ballast control room operator. On-the-job training should only be given after a person has been taught the basic principles of MODU ballast control. When operating in a marine environment, MODU's should have a marine organization aboard to be responsible for marine functions, such as lifeboatman. Furthermore, since the control room ballast operators are the only persons directly supervised by the master, the Safety Board believes that ballast control room operators on MODU's should be documented and certificated by the USCG so that there is some assurance that in the event of an emergency they can perform marine type functions, such as lifeboatman.

The Safety Board believes that there is not any substantial difference regarding stability and ballast control principles and problems between self-propelled and nonself-propelled semisubmersible MODU's when moored. Both types of MODU's should have the same requirements whereby a licensed person is in charge to supervise the ballast control room operators and to be responsible for the other safety requirements contained in the USCG regulations.

Management

The OCEAN RANGER was drilling under contract to MOBIL, but ODECO was responsible for the safe operation of the OCEAN RANGER as a vessel. However, ODECO did not: (1) define adequately the duties and responsibilities of the person-in-charge (toolpusher) or the master regarding marine safety functions on the OCEAN RANGER; (2) provide suitable training programs or establish standard operating procedures for control room operators; (3) provide training and written guidance in emergency procedures for operating the ballast control system; and (4) provide a sufficient indoctrination period for masters newly reporting aboard. The Safety Board believes that the foregoing management deficiencies contributed to the listing problem on February 15th.

ODECO's management was responsible for clearly defining the toolpusher's and the master's responsibilities regarding marine safety functions. While ODECO assigned an industrial relations representative (IRR) to assist the toolpusher with training, safety procedures, and emergency drills, ODECO did not require the IRR to be a certificated lifeboatman, or possess a USCG license. Control room operators were provided with on-the-job training, but ODECO did not provide written guidance for this training or develop a description of the control room operator's duties and responsibilities. Testimony from several former crewmembers of the OCEAN RANGER who were familiar with the ballast control system revealed that no standard practice was ever established as to what valves could be left open or what particular ballast pumps would be used for maintaining trim on the rig. The rotation of crewmembers left ballasting procedures at the discretion of whoever was on duty. ODECO did not provide any standard operating procedures for the master or control room operators concerning pumping sequences, valve positions, or fueling and drill water loading procedures nor were any established on the

OCEAN RANGER. ODECO's management should have established standard operating procedures so that the continuity of these processes would not be disrupted during normal crew rotation. Furthermore, ODECO did not establish any emergency procedures relating to either electrical or mechanical malfunctions in the ballast control console.

Although ODECO hired qualified masters for the OCEAN RANGER, no attempt was made to provide a new master with systematic instruction about the drilling unit's ballast system; it was left to the master to learn the system on his own. The OCEAN RANGER's operating manual lacked vital information as to the ballast configurations that should be used to counteract the effects of accidental flooding in any of the lower hull compartments and procedures to be followed to prevent accidental flooding of the chain lockers. The Safety Board believes that had ODECO implemented a more effective training and familiarization program in the operation of the ballast control system, the crew of the OCEAN RANGER might have been able to overcome the ballasting problems it encountered on February 14 and 15.

Ballast Control System

The Safety Board's investigation of the ballast control system on the OCEAN RANGER revealed that the 110-volt control circuits could be affected by the introduction of seawater into the console as a result of one or more portlights breaking. A review of the ballast control system circuitry 32/ and an examination of pushbutton switches and holding relays of the same type used in the OCEAN RANGER ballast control console disclosed that, if seawater completed the electrical circuit at the base of the switches, the holding relays for the tank valves could be activated which, in turn, would activate the solenoid valves and admit compressed air into the valve controllers, thus, opening the valves. Seawater dripping onto the terminals of the holding relay also could cause the valves to open by themselves even if the switches were not affected. In both instances, the red "close" indicator lights would go out. Also, if the 24-volt indicating lamp circuits were affected by the seawater, the red indicator lights would go out, giving the impression that the valves were opening when, in fact, they were not. Because of an electrical malfunction caused by the seawater splashing on the console, the control console probably was shut down electrically and the crew attempted to control the ballast manually by inserting the actuating rods in the solenoid valves. The Safety Board believes that the intercepted transmissions about "valves opening and closing by themselves" indicated an electrical malfunction in the ballast control console.

The ballast control room console was not required to be watertight by either the USCG or ABS because the ballast control room was designed to be watertight. There were no exterior doors or hatches installed in the space. Fixed 3/8-inch tempered glass was installed in each porthole with no provision for opening to the outside. Total ballast control was not lost in the event of an electrical malfunction caused by water splashing onto the console because of the backup manual control system. The Safety Board believes that because of its location in a watertight space, the ballast control console was suitably designed.

In normal operation, the visual display of valve positions provided the ballast control operator with an overall picture of which valves were open and what systems were lined up. The design of the ballast control system on the OCEAN RANGER did not provide any secondary display of information, such as a separate mimic board, to inform the operator of valve positions and pump operation if electrical power to the ballast control console was turned off. Since the actuating rods did not indicate clearly the positions of the

32/ MHI Drawing No. P-3113 - Ballast Control Console.

solenoids, the ballast control room operator had to commit to memory or record the valve positions if it became necessary to operate the ballast system manually. Furthermore, there was no evidence that anyone aboard the OCEAN RANGER on February 15 had ever used the actuating rods or that there were any operating instructions for their use. Therefore, the Safety Board believes that ODECO should provide detailed instructions for the emergency operation of the ballast control systems aboard its other semisubmersible drilling units.

There were two switches labeled "source" on the vertical panels of the ballast control console. One switch was located on the starboard hull side and the other switch was located on the port hull side. Testimony from a former master, a former control room operator, and a former rig electrician gave different opinions as to what these switches actually controlled. The source switches merely cut off power to the electric ballast and drill water pump pressure indicators. The actual circuit breakers to deenergize the console were inside the vertical panels which may have confused the OCEAN RANGER crew on February 14 and 15 and may have delayed the deenergizing of the control console.

The ballast control room operator was responsible for maintaining the draft of the OCEAN RANGER as well as the trim and heel. The operator's only method of determining the draft, other than by calculation, was to look out the portholes at the four corner columns and read the figures on the draft gauges. The need to use a portable searchlight would have made this method difficult at night in rough seas or dense fog. Securing the deadlights over the portlights also would have made regular observations of the draft gauges awkward. Internal draft gauges with readouts directly in the control board, as found on other installations, would have provided a more accurate and quicker method of determining draft, and allowed the deadlights to be secured during severe weather.

Testimony by former ballast control room operators on the OCEAN RANGER also revealed that the tank level indicators, referred to as "king gauges," were mounted in racks at the after side of the circular control room, so that when the control room operator faced aft, the portside gauges were to his left and the starboard side gauges were to his right, thus placing the gauges opposite to the side they were measuring. This is contrary to normal marine practice where port and starboard orientation is maintained regardless of how a person is facing. One control room operator stated this arrangement was confusing to anyone operating the system for the first time.

The pumprooms in the port and starboard lower hulls of the OCEAN RANGER were located in the after ends of each hull adjacent to the propulsion rooms. (See figure B-1, appendix B.) This design limited the amount of tankage aft for trimming purposes when operating at the 80-foot draft condition. Using the forward end tanks for trimming purposes can result in accidental flooding, which quickly can introduce a significant trim or heel. When the rig is trimmed forward, the after location of the pumps at such a great distance from the forward tanks reduces the amount of net positive suction head or lift available to the pumps. If the pumps had been located closer to or at midships as in many semisubmersible MODU designs, the amount of lift necessary to deballast the forward tanks, including less friction loss, would have been reduced.

CONCLUSIONS

Findings

1. The OCEAN RANGER capsized and sank between 0305 and 0310 on February 15, 1982, about 166 nmi east of St. John's, Newfoundland, Canada.

2. The OCEAN RANGER capsized and sank as a result of flooding of its port bow chain locker and upper hull caused by wave action after it experienced a 10° to 15° port bow list about 0100 on February 15, 1982.

3. The 10° to 15° port bow list reported at 0112 was the result of transferring liquids from other tanks or otherwise filling of empty or partially empty forward ballast tanks in the lower hulls through the ballast system and was not the result of any structural failure.

4. The transferring to or filling of the empty or partially empty forward ballast tanks was the result of an electrical malfunction in the ballast control console and the inability of the crew thereafter to manually operate the ballast control system's solenoids effectively.

5. The electrical malfunction in the ballast control console was the result of water splashing on the console from broken portlights.

6. At the 80-foot operating draft, there was limited ballast space aft for counterflooding; consequently, the crew of the OCEAN RANGER would have been unable to quickly correct a 10° to 15° list. The reduced pumping rate for dewatering all forward tanks and the inability of the ballast water pumps to dewater some of the forward ballast tanks and to only partially dewater others would have further limited their ability to recover from the list.

7. The OCEAN RANGER had adequate intact stability to withstand the storm on February 14th and 15th provided no other overturning forces were acting on the MODU.

8. The master's and control room operator's practice of keeping the center ballast tanks full and having empty or partially empty forward ballast tanks, rather than using the ballast arrangement of keeping center tanks empty as suggested in the OCEAN RANGER's Operating Manual, resulted in a condition in which a 10° to 15° list could develop rapidly.

9. Even though crewmembers escaped from the OCEAN RANGER in lifejackets and in a lifeboat and were sighted by would-be rescuers, there were no survivors to the accident.

10. When abandoning the MODU, the crew of the OCEAN RANGER did not have adequate protective equipment for the cold environment which resulted in their rapid immobilization and death due to hypothermia.

11. Although the newly installed Watercraft lifeboats aboard the OCEAN RANGER were U.S. Coast Guard approved designs, their installation had not been approved by the U.S. Coast Guard.

12. The standby vessels provided by MOBIL did not have adequate equipment for recovering persons from the water under adverse weather conditions and the crews of the standby vessels were not provided with adequate thermal protection for working on deck in cold weather.

13 The OCEAN RANGER's lifeboat which had persons aboard capsized because of the free surface effect of water entering through the hole in the bow and the weight of the persons simultaneously moved to one side of the lifeboat to debark.

14. The master of the OCEAN RANGER was not provided a sufficient indoctrination period with the alternate master when he reported for duty on January 26, 1982.

15. The master of the OCEAN RANGER, who had been on board for only 20 days, did not have sufficient knowledge of the operation of the ballast system when he assumed his duties.

16. Although the cause of the breaking of the portlights could not be determined from the available evidence, the adequacy of existing standards for the installation of portlights should be evaluated by the U.S. Coast Guard.

17. The OCEAN RANGER's Operating Manual did not contain adequate information or provide guidance to the master and control room operator of emergency procedures to be followed in the event of an electrical malfunction in the ballast control console.

18. The OCEAN RANGER's Operating Manual did not provide adequate guidance regarding the accidental flooding of lower hull compartments or tanks of semisubmersible MODU's and precautions to be taken to prevent flooding of chain lockers.

18. The U.S. Coast Guard, the American Bureau of Shipping, and the International Maritime Organization MODU standards do not take into consideration the effects of accidental flooding of lower hull tanks and compartments on semi-submersible MODU's.

19. The NORDCO, Ltd., weather forecast at 1930 on February 14 was substantially correct and gave the crew of the OCEAN RANGER sufficient and timely information as to the severity of the storm.

20. ODECO should have used a U.S. Coast Guard approved facility for servicing the liferafts aboard the OCEAN RANGER to insure that the liferafts were serviced properly.

21. About half of the lifejackets removed from the bodies of the 22 crewmembers of the OCEAN RANGER which were recovered were not USCG-approved designs, although the lifejackets had USCG-approval markings and had been inspected and passed by a USCG inspector.

22. The MOBIL emergency procedures manual did not provide adequate guidance in case of heavy weather damage.

23. The station bill (muster list) on the OCEAN RANGER did not contain sufficient information to determine if certificated lifeboatmen were assigned to each lifeboat.

24. The duties and responsibilities of the toolpusher (person-in-charge), the master, and the control room operators on the OCEAN RANGER were not well defined by ODECO.

25. ODECO did not provide sufficient training to control room operators prior to assignment.

26. ODECO does not have adequate procedures to insure that its vessels are kept in compliance with U.S. Coast Guard regulations and are currently inspected.

27. The U.S. Coast Guard does not have an established procedure for notifying vessel owners when their U.S. Coast Guard Certificates of Inspection are about to expire.

28. There is a need for the U.S. Coast Guard to establish a consistent policy for the interim reinspection of all U.S. flag MODU's worldwide.

29. The buoyancy chambers on the recovered liferafts had seperated; there is a need for the U.S. Coast Guard to determine the cause of the separation and to upgrade its liferaft specifications.

30. Since all the OCEAN RANGER's lifeboats were either damaged or lost, there is a need for a review of lifeboat launching systems on MODU's by the U.S. Coast Guard and the offshore oil industry.

31. The U.S. Coast Guard should require U.S. MODU's to have standby vessels since they are a necessary part of the MODU survival planning, especially for those MODU's which operate in cold waters or isolated locations.

32. The establishment by the U.S. Coast Guard of minimum qualification standards for masters, persons-in-charge, and ballast control room operators and manning standards for MODU's is long overdue.

33. The enforcement of USCG regulations relating to MODU's is hampered because the persons-in-charge of MODU's are not licensed by the USCG.

34. Since the person-in-charge of a MODU is normally designated the person in command of a lifeboat, the Coast Guard should require that all persons-in-charge be certificated lifeboatmen.

35. ODECO should provide a permanently installed means of dewatering chain lockers and internal draft gauges on all its new and existing MODU's.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the capsizing and sinking of the U.S. mobile offshore drilling unit OCEAN RANGER was the flooding of the anchor chain lockers in the forward columns when it took on a 10° to 15° list in the direction of the severe wind and wave action. The list was a result of the transfer of liquids from other tanks or otherwise filling empty or partially empty forward ballast tanks in the OCEAN RANGER's lower hull after its ballast control console suffered an electrical malfunction from seawater entering through broken portlight(s) and the crew's inability thereafter to manually control the operation of the ballast control system's valves to correct the list. Contributing to the capsizing and sinking was the failure of the management of ODECO to have an effective program to provide sufficient training and familiarization in the operation of the ballasting system to pertinent personnel in the OCEAN RANGER and the failure of the portlight(s) for undetermined reasons. Contributing to the loss of life was: the lack of personal thermal protection equipment for the OCEAN RANGER's crewmembers for the effect of hypothermia; the difficulty of launching lifeboats and liferafts from the OCEAN RANGER in the severe wind and sea conditions; and inadequate equipment aboard the rescue vessels for recovering persons from the sea under adverse conditions.

RECOMMENDATIONS

During its investigation of this accident, the National Transportation Safety Board made the following recommendations on July 8, 1982:

--to the U.S. Coast Guard:

> Require that all U.S. mobil offshore drilling units that operate in waters where hypothermia can greatly reduce an individual's survival time carry an exposure suit for each person on board, similar to that required by 46 CFR 94.41-5(c). (Class II, Priority Action) (M-82-35)

Status.--The Coast Guard has initiated a regulatory project to require exposure suits on certain commercial vessels, including all U.S. flag MODU's and those foreign flag MODU's that operate on the outer continental shelf of the United States. The requirements for exposure suits would not apply to any MODU operating solely in waters between 35° north latitude and 35° south latitude, or on the outer continental shelf south of 38° north latitude, since the water temperature in these areas is usually above 60° F (15.5° C). The recommendation has been classified "Open--Acceptable Action," based on the proposed regulatory action.

--to the Ocean Drilling and Exploration Company:

> Provide all your mobile offshore drilling units that operate in waters where hypothermia can greatly reduce an individual's survival time with exposure suits for each person on board, similar to that required by 46 CFR 94.41-5(c). (Class II, Priority Action) (M-82-36)

Status.-- On May 19, 1982, ODECO ordered exposure suits for 150 percent of the persons aboard their offshore drilling rigs, regardless of location. By July 1982, all ODECO drilling units in colder waters had been equipped with exposure suits and the remaining drilling units had been provided with exposure suits by November 1982. The recommendation has been classified "Closed--Acceptable Action."

--to the International Association of Drilling Contractors:

> Recommend to its members that they provide exposure suits for each person on board mobile offshore drilling units which operate in waters where hypothermia can greatly reduce an individual's survival time, similar to that required by 46 CFR 94.41-5(c). (Class II, Priority Action) (M-82-37)

Status.--The International Association of Drilling Contractors has not responded as of this date.

As a result of its investigation, the National Transportation Safety Board made the following recommendations:

--to the U.S. Coast Guard:

> Expedite the promulgation of regulations regarding personnel qualifications and manning standards for mobile offshore drilling units. (Class II, Priority Action) (M-83-5)

Require that the master and the person-in-charge of a mobile offshore drilling unit be licensed and that their licenses be endorsed as qualified in mobile offshore drilling operations, including knowledge of U.S. Coast Guard regulations, stability characteristics of mobile offshore drilling units, the operation of ballast systems on mobile offshore drilling units, and the use of lifesaving equipment peculiar to mobile offshore drilling units. (Class II, Priority Action) (M-83-9)

Require that the person-in-charge of a mobile offshore drilling unit also be a certificated lifeboatman. (Class II, Priority Action) (M-83-10)

Require that the station bill on mobile offshore drilling units identify by name the certificated lifeboatmen required by the U.S. Coast Guard Certificate of Inspection. (Class II, Priority Action) (M-83-11)

Provide guidance to officers-in-charge of marine inspection which relates the manning requirement for certificated lifeboatmen on a MODU to the size of the lifeboats and the number of nonmarine crew aboard a mobile offshore drilling unit and not to the mode of operation of the unit. (Class II, Priority Action) (M-83-12)

Require that a control room operator on self-propelled and nonself-propelled semisubmersible mobile offshore drilling units be certificated or licensed and be qualified in the stability characteristics and ballasting procedures of mobile offshore drilling units and as a certificated lifeboatmen. (Class II, Priority Action) (M-83-13)

Require that the operating manual for a self-propelled or nonself-propelled semisubmersible mobile offshore drilling unit include guidance regarding: (1) accidental flooding of empty or partially empty lower hull compartments or tanks and the appropriate countermeasures; (2) any limitations in the functioning of the ballast pumps due to trim or heel; and (3) precautions for preventing downflooding into chain lockers from wave action. (Class II, Priority Action) (M-83-14)

Revise the stability standard for semisubmersible mobile offshore drilling units to include the capability of the drilling units to survive the flooding of any two adjacent lower hull compartments or tanks and to pump out any of the lower hull tanks after the assumed flooding. (Class II, Priority Action) (M-83-15)

Urge that the International Maritime Organization review and amend or extend, as necessary, the following particulars of its 1979 Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU): (1) the stability standard for column stabilized units to include the capability of surviving flooding of any two adjacent lower hull compartments or tanks and to pump out any lower hull tanks after the assumed flooding; (2) requirements for lifeboat launching systems on MODU's; (3) inclusion in the lifesaving requirements for MODU's assignment at all times of a suitable vessel capable of retrieving persons from the water under severe weather conditions; and (4) inclusion in operating manuals guidance on the accidental flooding of empty or partially empty lower hull compartments or tanks on column stabilized units and the appropriate countermeasures. (Class II, Priority Action) (M-83-16)

Evaluate the suitability of currently approved lifeboat, liferaft, and other launching systems, such as free fall lifeboats, under severe weather conditions on mobile offshore drilling units and require modifications if currently approved systems are found inadequate. (Class II, Priority Action) (M-83-17)

Determine what caused the buoyancy chambers on the OCEAN RANGER liferafts to separate and upgrade U.S. Coast Guard liferaft specifications, as necessary. (Class II, Priority Action) (M-83-18)

Review current Coast Guard instructions regarding approval of lifesaving equipment to determine if adequate safeguards exist to prevent equipment from being approved before the prototype has been approved and make appropriate modifications, if necessary. (Class II, Priority Action) (M-83-19)

Require that a suitable vessel, capable of retrieving persons from the water under adverse weather conditions, be assigned to all U.S. mobile offshore drilling units at all times for the purpose of evacuating personnel from the unit in an emergency. (Class II, Priority Action) (M-83-20)

Establish a system to determine when Certificates of Inspection of U.S. vessels are about to expire and to notify owners accordingly. (Class II, Priority Action) (M-83-21)

Cancel the proposal to amend 46 CFR 107.269 which would discontinue reinspections of mobile offshore drilling units in international service and withdraw the policy guidance that suspended reinspections of mobile offshore drillings units in international service as of January 7, 1983. (Class II, Priority Action) (M-83-22)

Evaluate the adequacy of existing standards for portlight installations in ballast control rooms and other critical locations in columns of semisubmersible mobile offshore drilling units and require that modifications be made, if necessary. (Class II, Priority Action) (M-83-23)

--to Ocean Drilling and Exploration Company:

Require that the station bill on ODECO mobile offshore drilling units identify by name the certificated lifeboatmen required by the U.S. Coast Guard Certificate of Inspection. (Class II, Priority Action) (M-83-24)

Require that all regular and relief masters and the persons-in-charge be fully instructed and qualified in the operation of the ballast control system of semisubmersible mobile offshore drilling unit to which assigned. (Class II, Priority Action) (M-83-25)

Define in detail the nonindustrial duties and responsibilities of the master and the person-in-charge on all ODECO mobile offshore drilling units in all modes of operation. (Class II, Priority Action) (M-83-26)

Define in detail the necessary qualifications for ballast control room operators on ODECO semisubmersible mobile offshore drilling units, and require that the qualifications be met and that potential control room operators attend a stability school before being assigned to a MODU as a control room operator. (Class II, Priority Action) (M-83-27)

Review and revise the operating manuals for self-propelled and nonself-propelled semisubmersible mobile offshore drilling units to include general guidance on the duties of ballast control room operators and specific guidance regarding: (1) accidental flooding of empty or partially empty lower hull compartments or tanks and the appropriate countermeasures; (2) any limitations in the functionings of the ballast pumps due to trim or heel; (3) precautions for preventing flooding into chain lockers from wave action; (4) the effect of random seas on the drilling unit's roll period; and (5) duties and responsibilities of ballast control room operators. (Class II, Priority Action) (M-83-28)

Install a permanent pumping system to dewater the chain lockers on all new and existing mobile offshore drilling units. (Class II, Priority Action) (M-83-29)

Include in the operating manuals for semisubmersible mobile offshore drilling units detailed operating instructions for emergency operation of the ballast system in the event that the primary control system fails. (Class II, Priority Action) (M-83-30)

Install internal draft gauges with direct readouts in the ballast control rooms on semisubmersible mobile offshore drilling units. (Class II, Priority Action) (M-83-31)

Establish procedures to ensure that requests to the U.S. Coast Guard for renewal of U.S. Coast Guard Certificates of Inspection are initiated in time to avoid lapse of U.S. Coast Guard Certificates of Inspection for mobile offshore drilling units, especially those operating in international service. (Class II, Priority Action) (M-83-32)

Establish procedures to ensure that U.S. Coast Guard approved liferafts are serviced only at approved servicing facilities. (Class II, Priority Action) (M-83-33)

--to MOBIL Oil of Canada, Ltd.:

Require that vessels engaged as standby boats for mobile offshore drilling units be equipped with apparatus for recovering persons from the water under adverse sea conditions and that the crews of standby boats be provided with exposure suits designed for rescue operations. (Class II, Priority Action) (M-83-34)

Revise the Contingency Plans and Emergency Procedures Manual for mobile offshore drilling units to include a detailed disaster action plan for heavy weather damage similar to the disaster action plans for fire, explosion, or collision. (Class II, Priority Action) (M-83-35)

--to the American Bureau of Shipping:

Revise the stability criteria contained in the Rules for Building and Classing Mobile Offshore Drilling Units to require that semisubmersible mobile offshore drilling units include the capability to survive the flooding of any two adjacent lower hull compartments or tanks and to pump out any of the lower hull tanks after the assumed flooding. (Class II, Priority Action) (M-83-36)

--to the International Association of Drilling Contractors:

Recommend that members review the suitability of lifeboat, liferaft, and other launching systems on mobile offshore drilling units under severe weather conditions, and promote the development of improved launching systems if the current systems are found inadequate. (Class II, Priority Action) (M-83-37)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JIM BURNETT
Chairman

/s/ PATRICIA A. GOLDMAN
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ G. H. PATRICK BURSLEY
Member

/s/ DONALD D. ENGEN
Member

February 8, 1983

APPENDIXES

APPENDIX A

GLOSSARY OF TERMS USED IN THE OFFSHORE DRILLING INDUSTRY

[1] **Drill string or drill pipe.** The heavy seamless tubing used to rotate the drill bit and to circulate the drilling fluid.

[2] **Hung the pipe, hung off, or hang off.** The process by which a joint connecting two lengths of drill pipe is brought up into the BOP stack 1/ and disconnected. See figure A1.

[3] **Lower pipe ram.** The lowest of four sets of rams in the BOP stack. The lower three pipe rams are capable of closing around the drill pipe and holding the entire weight of the drill string. The upper ram or shear ram has blades which are capable of cutting the drill pipe when closed. See figure A1.

[4] **Sheared off the pipe.** Instead of disconnecting a joint in the drill string, the drill pipe was cut by the shear rams in the BOP stack.

[5] **Lateral motion off location.** This means that the lateral motion of the drilling rig at the sea surface was causing an angle, measured from the vertical, of the drill string at the ball joint on the top of the BOP. See figure A1.

[6] **Marine riser.** - The pipe that encloses the drill string. While drilling, fluids are pumped down through the drill pipe to clean cuttings from the bore hole, cool the bit and maintain well pressure control. These fluids are recovered and reused. The fluids return to the drilling platform from the BOP stack on the ocean floor through the marine riser.

[7] **Hung off.** - See [2] above.

[8] **Hang off.** - See [2] above.

[9] **Compensator hoses.** - Flexible hoses used to carry drilling fluids from the pumps to the upper end of the drill pipe located in the derrick.

[10] **Derrick.** - The vertical steel structure used to support the drill pipe and other equipment which has to be raised or lowered during well-drilling operations. See figure A1.

[11] **Middle rams.** - The middle set of rams in the BOP stack. See (3) above.

1/ BOP stack refers to the equipment placed on the ocean floor to prevent a blow out or sudden pressure release from the well.

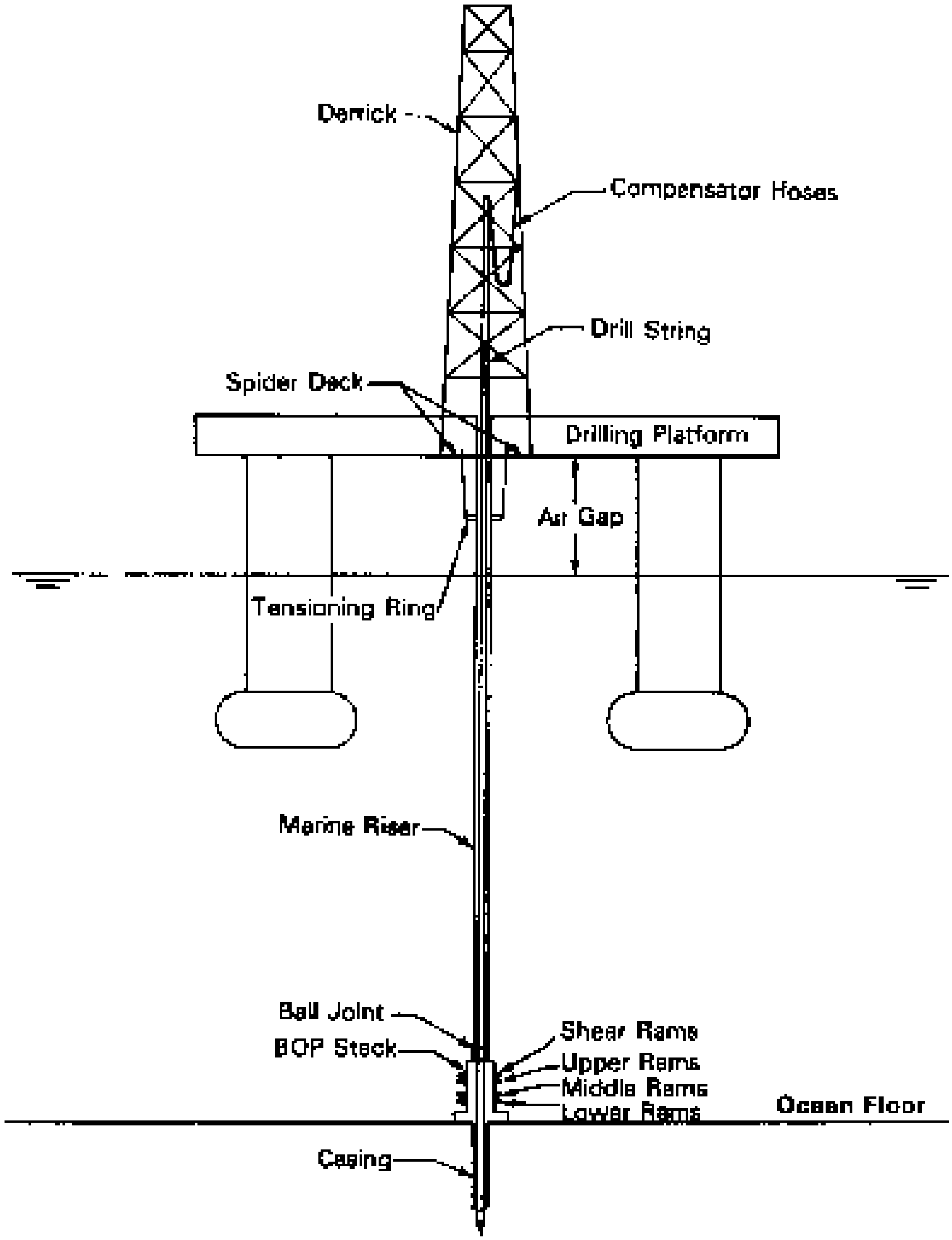


Figure A-1.--Sketch showing the relationship of some typical equipment used in offshore drilling.

[12] **Bit.** – The cutting tool at the lower end of the drill pipe.

[13] **Casing.** Tubular steel used to line the hole and provide space for the return flow of drilling fluids.

[14] **Shear rams.** – The uppermost rams in the BOP stack designed to cut the drill pipe. See (3) above.

[15] **Tensioning ring.** – The ring on the marine riser to which the tensioning wires are attached. The tensioning system supports the marine riser while compensating for the vertical motion of the MODU.

[16] **Spider deck.** – The lower deck of the upper hull under the derrick.

[17] **Heaves.** – The vertical motion of a MODU in a seaway.

[18] **Anchor tensions.** – The amount of strain in the anchor mooring wires holding the MODU in position.

[19] **Air gap.** – The vertical distance between the surface of the sea and the underside of the upper hull.

APPENDIX B

VESSEL DATA

Vessel Characteristics

	Feet
Length Overall (Over Anchor Bolsters)	408.2
Length (Bow to Center of Rudder Stock)	393.75
Beam Overall (Over Anchor Bolsters)	298.4
Beam (Moulded)	262.0
Depth to Under-Side of Upper Hull Girders	130.0
Depth to Bottom of Lower Deck	131.5/134.0
Depth to Top of Upper Deck	151.5
Depth to Drill Floor	175.0
Depth to Top of Derrick (About)	394.3
Maximum Operating Draft (Afloat)	90.0
Minimum Operating Draft (Afloat)	45.0
Maximum Transit Draft	30.0

Class: American Bureau of Shipping AMS✠A1 M Column Stabilized Drilling Unit
Unrestricted Operation in Floating Conditions
Operating Water Depth (Rated with 1,650 Ft. Chain & 5,600 Ft. Wire) - 1,500 Feet
Operating Water Depth (Rated with 3,100 Ft. Chain & 5,600 Ft. Wire) - 3,000 Feet
Gross Tons - 14,913
Net Tons - 9,284
Displacement (at 80 feet operating draft) - 38,940 long tons
Deadweight (at 80 feet operating draft) - 16,408 Long tons

TANK CAPACITIES

Lower Hull Tanks		Contents	Capacity Long Tons
PT 1 and	ST 1	Ballast	512.2
PT 2 and	ST 2	Ballast	959.9
PT 3 and	ST 3	Ballast	959.9
PT 4 and	ST 4	Ballast	816.6
PT 5 and	ST 5	Drill Water	797.9
PT 6 and	ST 6	Fuel Oil	667.6
PT 7 and	ST 7	Ballast	807.0
PT 8 and	ST 8	Ballast	710.6
PT 9 and	ST 9	Ballast	710.7
PT 10 and	ST 10	Ballast	710.6
PT 11 and	ST 11	Ballast	710.7
PT 12 and	ST 12	Fuel Oil	567.6
PT 13 and	ST 13	Drill Water	787.2
PT 14 and	ST 14	Ballast	816.6
PT 15 and	ST 15	Ballast	817.9
PT 16 and	ST 16	Ballast	347.5

Upper Hull Tanks	
Fuel oil overflow	12.2
Steam Generator Fuel Oil	6.7
Emergency Generator Fuel Oil	3.2
Helicopter Fuel Oil	18.9
Fuel Oil Settling	83.4
Fuel Oil Day Tank	76.1
Lube Oil Storage	16.0
Salt Water	112.0
Drill Water	103.9
Potable Water	179.7
MUD Pit No. 1	105.6
MUD Pit No. 2	106.0
MUD PT No. 3	104.2
MUD PIT No. 4	105.4
Slugging Pit	35.3

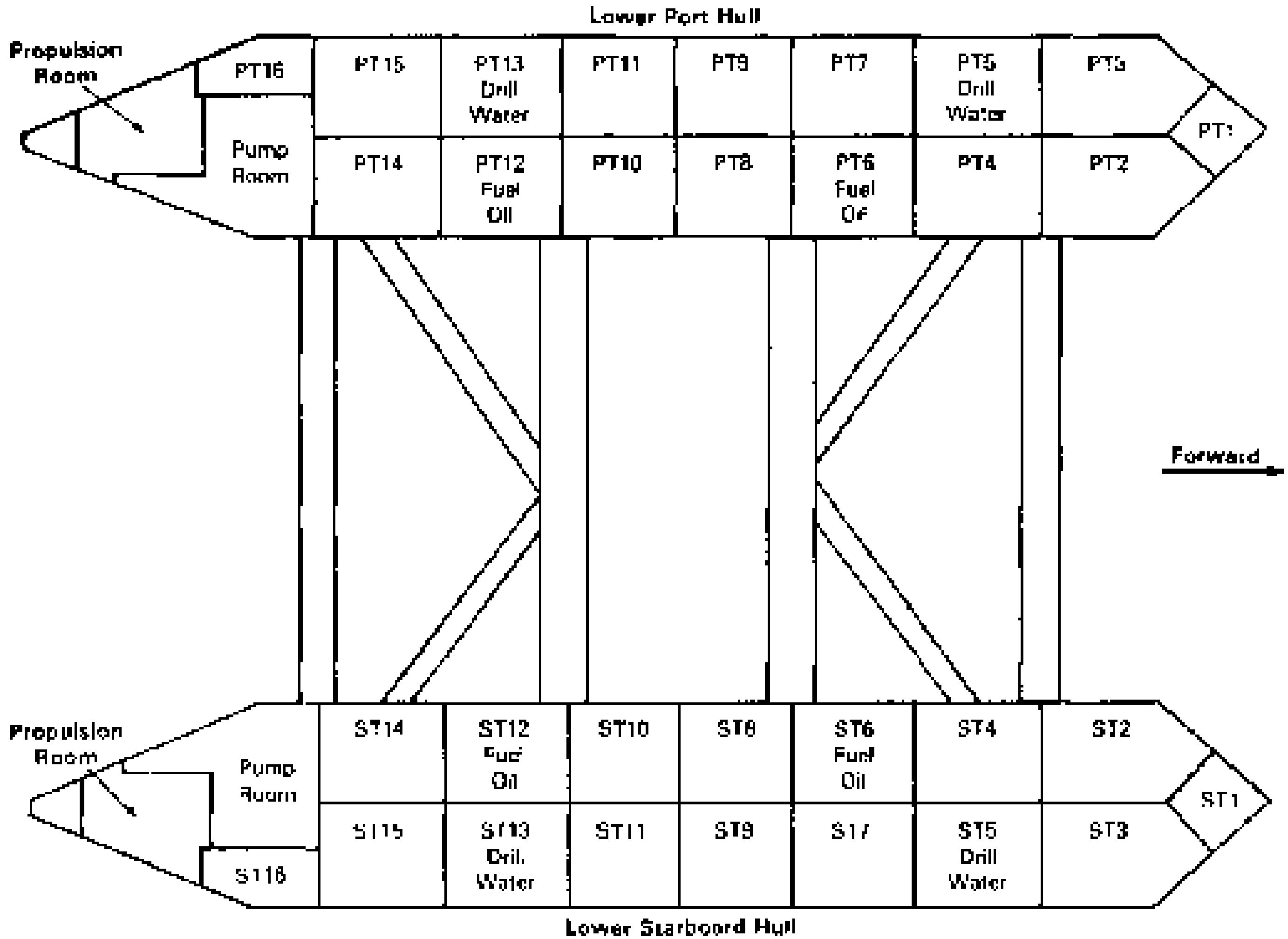


Figure B-1.--Arrangement of tanks in the OCEAN RANGER's lower hulls.

APPENDIX C

ABS STABILITY REQUIREMENTS – 1973

3.13 Stability

3.13.1 *General*

All units are to have positive stability in calm water equilibrium position, for the full range of drafts, whether as operating position for towing or drilling afloat, or as temporary positions when raising or lowering. In addition, all units are to meet the stability requirements set forth below for all applicable operating positions.

3.13.2 *Stability Afloat*

a *Intact Stability* All units are to have sufficient stability (righting ability) to withstand the overturning effect of the force produced by a steady wind from any horizontal direction in accordance with the stability criteria given in 3.15 for all operating conditions; afloat, transit and drilling. Realistic operating conditions are to be evaluated, with the capability to continue drilling operations with a steady wind velocity of not less than 36 meters per second (70 knots) for offshore service. The capability is to be provided to change the mode of operation of the unit to that corresponding to a severe storm condition, with steady wind velocity of not less than 51.5 meters per second (100 knots), in a reasonable period of time. In all cases, the limiting wind velocities are to be specified and instructions are to be included in the Operating Booklet for changing the mode of operation by redistribution of the variable load and equipment, by changing drafts, or both. Where the unit is to be limited in operation to sheltered locations consideration will be given to a reduced wind velocity of not less than 25.8 meters per second (50 knots) for normal operating conditions.

b *Damage Stability* All units are to have sufficient stability to withstand the flooding from the sea of any one main compartment which may reasonably be expected to be flooded for any operating condition which has been reviewed under a above. The unit is to possess sufficient reserve stability in the damaged condition to withstand the additional overturning moment of a 25.8 meters per second (50 knot) wind superimposed from any direction. In this condition, the final waterline

is to be below the lower edge of any opening through which downflooding may take place. The ability to compensate for damage incurred, by pumping out or by ballasting other compartments, etc., or by mooring forces, is not to be considered as alleviating the above requirements, and it is also assumed that the unit is floating free of mooring restraints. The detailed requirements for damage stability are indicated in the applicable section of these Rules for the type of unit under consideration.

3.15 Stability Criterion Under Wind Force

3.15.1 *Intact Condition*

Cross curves of stability and wind heeling moment curves with supporting calculations are to be prepared covering the full range of operating drafts including transit conditions. Where drilling equipment is of the nature that it can be lowered and stowed, additional wind heeling moment curves may be required and such data should clearly indicate the position of such equipment.

Curves of dynamic stability similar to Fig. 3.1 are to be prepared for a sufficient number of conditions covering the range of operating drafts. In all cases, except column stabilized units, the area under the righting moment curve to the second intercept or downflooding angle, whichever is less, is to be not less than 40% in excess of the area under the wind heeling moment curve to the same limiting angle.

For column stabilized units, the area under the righting moment curve to the angle of downflooding is not to be less than 30% in excess

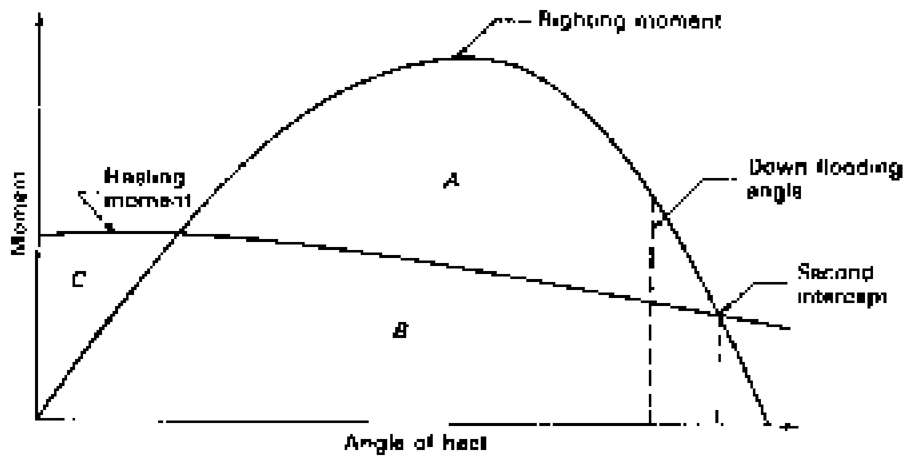


Fig. 3.1 Dynamic stability curve

of the area under the wind heeling moment curve to the same limiting angle. In all cases, the righting moment curve is to be positive over the entire range of angles from upright to the second intercept.

In calculating wind heeling moments for shipshape hulls the curve may be assumed to vary as the cosine function of vessel heel. For all other units, the curve is to be calculated for a sufficient number of heel angles to define the curve.

5.11 Clearance

5.11.1 *Afloat Condition*

In afloat operating condition, the clearance from the underside of the platform deck structure to the design draft is not to be less than 60% of the design wave height plus 1.5 meters (5 feet). Model test data or prototype experience will be considered in reduction of this figure.

5.11.2 *On-bottom Condition*

For on-bottom condition, clearances are to be in accordance with those specified for self-elevating units in 4.5.4.

5.13 Damage Stability

In assessing the damage stability of column stabilized drilling units as required by 3.13.2, the following assumed damage conditions will apply.

1 Columns on the periphery of the unit will be assumed to be damaged only and the damage will occur in the exposed portions of the column.

2 Columns which are subdivided into watertight compartments by watertight flats will generally be assumed to be damaged within any one compartment enclosed by watertight flats. Where a watertight flat is located within 1.5 meters (5 feet) of the normal operating drafts, the damage will be assumed to have occurred in both compartments above and below the watertight flat in question.

3 Columns, which are divided by both vertical watertight bulkheads and horizontal watertight flats, will be assumed to be damaged between the vertical bulkheads where the angle between bulkheads exceeds 45 degrees. Where the angle between the vertical bulkheads is 45 degrees or less, the damage will be assumed to have occurred in both compartments. The vertical extent of damage will be as indicated in 2 above.

4 Penetration of the columns will assume a depth of damage of 1.5 meters (5 feet).

5 Footings are to be treated as damaged when operating at a light or transit condition in the same manner as indicated in 1 through 4 above.

6 All piping, ventilating systems, trunks, etc. within this extent are to be assumed damaged. Positive means of closure are to be provided to preclude progressive flooding of other intact spaces. See 7.11.

1.11 Operating Booklet

For each unit an operating booklet is to be prepared as a condition of Classification and to the satisfaction of the Bureau. The booklet is to contain the following information, as applicable to the particular unit, so as to provide suitable guidance to the operating personnel with regard to safe operation of the unit.

General description of the unit, including experiment results, light ship data, etc.

Pertinent data for each operating condition, including design loading, wave height, bottom condition, draft, etc.

General arrangement showing watertight compartments, closures, vents, permanent ballast, allowable deck loadings, etc.

Hydrostatic curves or equivalents

Capacity plan showing capacities of tanks, center of gravities, free surface corrections, etc.

Instructions for operation of the unit including adverse weather, changing mode of operation, any inherent limitations of operations, etc.

Stability information in the form of maximum KG versus draft curve or other suitable parameters based upon compliance with the required intact and damaged stability criteria

Representative examples of loading conditions for each mode of operation together with means for evaluation of other loading conditions

APPENDIX D

USCG MODU STABILITY REQUIREMENTS

Subpart C—Stability

§ 108.301 Stability: Definitions.

For the purposes of this subpart:

(a) "Normal operating condition" means a condition of a unit when loaded or arranged for drilling, field transit, or ocean transit.

(b) "Severe storm condition" means a condition of a unit when loaded or arranged to withstand the passage of a severe storm.

(c) "Downflooding" means the entry of seawater through any opening which cannot be rapidly closed watertight, into the hull, superstructure, or columns of an undamaged unit due to heel, trim, or submergence of the unit.

(d) "Downflooding angle" means the static angle from the calm seawater surface at a unit's waterline to the first opening through which downflooding could occur, considering heel, trim, and submergence of the unit when subjected to a wind heeling moment (Hm) calculated in accordance with § 108.311.

§ 108.303 Stability requirements: General.

Each unit must be designed to have at least 5 cm (2 inches) of positive metacentric height in the upright equilibrium position for the full range of drafts, whether at the operating draft for navigation, towing, or drilling afloat, or at a temporary draft when changing drafts.

§ 108.305 Intact stability requirements.

(a) Each unit must be designed so that the wind heeling moments (Hm) and righting moments calculated for each of its normal operating conditions and severe storm conditions, when plotted on graph 108.305, define areas that satisfy the equation [Area (A)] ≥ [K] × [Area (B)] where—

(1) K = 1.4, except that if the unit is a column stabilized unit K = 1.3.

(2) Area (A) is the area on graph 108.305 under the righting moment curve between 0° and the second intercept angle or the angle of heel at which downflooding would occur, whichever angle is less; and

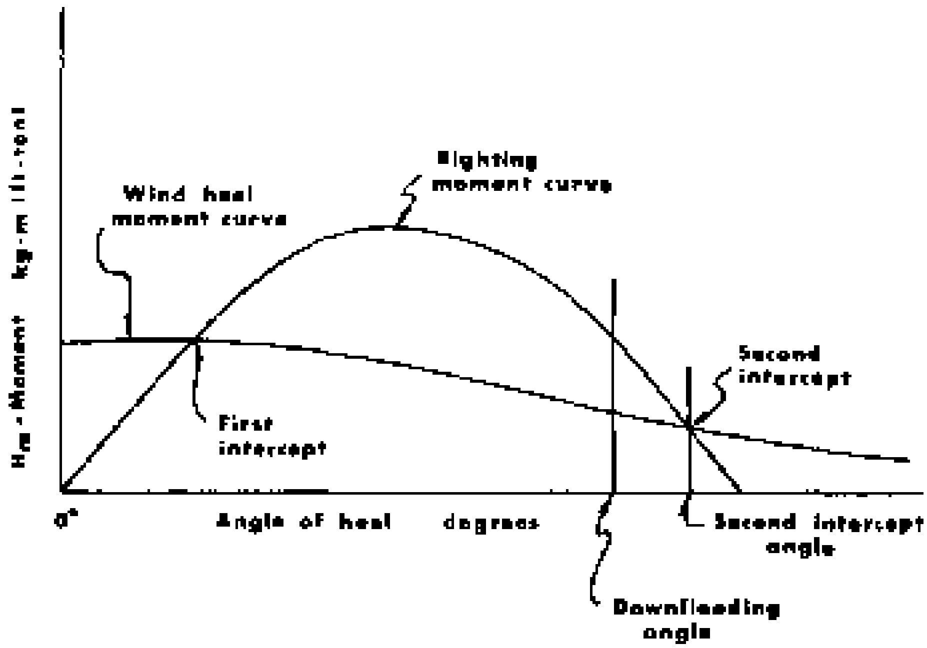
(3) Area (B) is the area on graph 108.305 under the wind heeling moment curve between 0° and the second intercept angle or the angle of heel at which downflooding of the unit would occur whichever angle is less.

(b) Each righting moment on graph 108.305 must be positive for all angles greater than 0° and less than the second intercept angle.

(c) For the purposes of this section, openings fitted with the weathertight closing appliances specified in § 108.114(b) are not considered as openings through which downflooding could occur if they can be rapidly closed and would not be submerged below the units' waterline prior to the first intercept angle, except that ventilation intakes and outlets for machinery spaces, crew spaces, and other spaces where ventilation is normally required are considered as openings through which downflooding could occur regardless of location.

(d) Each unit must be designed so that it can be changed from each of its normal operating conditions to a severe storm condition within a minimum period of time consistent with the operating manual required in § 109.121.

Graph 108.305 - Intact Stability Curves for a Given Normal Operating or Severe Storm Mode



§ 108.309 Stability on bottom.

Each bottom bearing unit must be designed so that, while supported on the sea bottom with footings or a mat, it continually exerts a downward force on each footing or the mat when subjected to the forces of wave and current and to wind blowing at the velocities described in § 108.311(b)(3).

§ 108.311 Calculation of wind heeling moment (Hm).

(a) The wind heeling moment (Hm) of a unit in a given normal operating condition or severe storm condition is the sum of the individual wind heeling moments (*H*) calculated for each of the exposed surfaces on the unit; i.e., $Hm = \Sigma H$.

(b) Each wind heeling moment (*H*) must be calculated using the equation $H = kv^2 C_h C_s A h$, where—

(1) *H* = wind heeling moment for an exposed surface on the unit;

(2) $k = 0.0623$ kilograms $(kg\text{-}sec^2)/m^4$ $(0.00338\ lb/(ft^2\text{-}knots^2))$;

(3) *v* = wind velocity of—

(i) 36 meters per second (70 knots) for normal operating conditions.

(ii) 51.5 meters per second (100 knots) for severe storm conditions.

(iii) 25.8 meters per second (50 knots) for damage conditions.

(4) *A* = projected area of an exposed surface on the unit;

(5) C_h = height coefficient for "A" from Table 108.311(a);

(6) C_s = shape coefficient for "A" from Table 108.311(b); and

(7) *h* = the vertical distance from the center of lateral resistance of the underwater hull to the center of wind pressure on "A".

(c) When calculating "A" in the equation described in paragraph (b) of this section—

(1) The projected area of each column or leg, if the unit has columns

or less, must not include shielding allowances;

(2) Each area exposed as a result of heel must be included;

(3) the projected area of a cluster of deck houses may be used instead of the projected area of each individual deck house in the cluster; and

(4) The projected area of open truss work may be calculated by taking 30% of the projected areas of both the front and back sides of the open truss work rather than by determining the projected area of each structural member of the truss work.

TABLE 108.311(a).—C_h Values

Height				
Meters		Feet		C_h
Over	Not exceeding	Over	Not exceeding	
0	15.3	0	50	1.00
15.3	30.5	50	100	1.10
30.5	46.0	100	150	1.20
46.0	61.0	150	200	1.30
61.0	76.0	200	250	1.37
76.0	91.5	250	300	1.43
91.5	106.5	300	350	1.48
106.5	122.0	350	400	1.52
122.0	137.0	400	450	1.56
137.0	152.5	450	500	1.60
152.5	167.5	500	550	1.63
167.5	183.0	550	600	1.67
183.0	198.0	600	650	1.70
198.0	213.5	650	700	1.72
213.5	228.5	700	750	1.75
228.5	244.0	750	800	1.77
244.0	256.0	800	840	1.79
Above 256		Above 840		1.80

NOTE: The "C_h" value in this table used in the equation described in section 108.311(b) corresponds to the value of the vertical distance in meters (feet) from the water surface at the design draft of the unit to the center of area of the "A" value used in the equation.

TABLE 108.311(b).—C_s Values

Shape	C_s
Cylindrical shapes	0.5
Hull (surface type)	1.0
Deckhouse	1.0
Cluster of deckhouses	1.1
Isolated structural shapes (cranes, angles, channels, beams, etc.)	1.5
Under deck areas (smooth surfaces)	1.0
Under deck areas (exposed beams and girders)	1.3
Rig derrick (each face and open truss works)	1.25

NOTE.—The value of C_s in this table used in the equation described in § 108.311(b) corresponds to the shape of the projected Area "A" in the equation.

§ 108.313 Submission of intact stability data.

Intact stability data submitted under § 107.305 of this subchapter must contain the righting moment curves and wind heeling moment curves described in graph 108.305 of this subpart, each with supporting calculations, for each of the unit's normal operating conditions and severe storm conditions.

§ 108.315 Damage stability requirements.

(a) Each unit must be designed so that, while in each of its normal operating conditions and severe storm conditions, its final equilibrium waterline would remain below the lowest edge of any opening through which additional flooding could occur if the unit were subjected simultaneously to—

(1) Damage causing flooding described in §§ 108.319 through 108.323; and

(2) A wind heeling moment calculated in accordance with § 108.311(b) using a wind velocity of 25.8 meters per second (50 knots).

(b) Each unit must have a means to close off each pipe, ventilation system, and trunk in each compartment described in § 108.321 or § 108.323 if any portion of the pipe, ventilation system, or trunk is within 1.5 meters (5 feet) of the hull.

§ 108.317 General damage stability assumptions.

For the purpose of determining compliance with § 108.315 of this subpart, the assumptions are made that during flooding and the resulting change in the unit's waterline—

(a) The unit is not anchored or moored; and

(b) No compartment on the unit is ballasted or pumped out to compensate for the flooding described in §§ 108.319–108.323 of this subpart.

§ 108.319 Compartments assumed flooded: General.

The individual flooding of each of the compartments described in § 108.321 and § 108.323 of this subpart must be assumed for the purpose of determining compliance with § 108.315(a) of this subpart. Simultaneous flooding of more than one compartment must be assumed only when indicated in § 108.321 and § 108.323.

§ 108.321 Flooding on self-elevating and surface type units.

(a) On a surface type unit or self-elevating unit, all compartments within 1.5 meters (5 feet) of the hull of the unit between two adjacent main watertight bulkheads, the bottom shell, and the uppermost continuous deck or first superstructure deck where superstructures are fitted must be assumed to be subject to simultaneous flooding.

(b) On the mat of a self-elevating unit, all compartments of the mat must be assumed to be subject to individual flooding.

§ 108.323 Flooding on column stabilized units.

(a) Watertight compartments that are outboard of, or traversed by, a plane which connects the vertical centerlines of the columns on the periphery of the unit, and within 1.5 meters (5 feet) of an outer surface of a column or footing on the periphery of the unit, must be assumed to be subject to flooding as follows:

(1) When a column is subdivided into watertight compartments by horizontal watertight flats, all compartments in the column within 1.5 meters (5 feet) of the unit's waterline before damage causing flooding must be assumed to be subject to simultaneous flooding.

(2) When a column is subdivided into watertight compartments by vertical watertight bulkheads, each two adjacent compartments must be assumed subject to simultaneous flooding if the distance between the vertical watertight bulkheads, measured at the column periphery, is equal to or less than one-eighth of the column perimeter at the draft under consideration.

(3) When a column is subdivided into watertight compartments by horizontal watertight flats and vertical watertight bulkheads, those compartments that are within the bounds described in paragraph (a)(2) and within 1.5 meters (5 feet) of the unit's waterline before damage causing flooding must be assumed to be subject to simultaneous flooding.

(b) Each compartment in a footing must be assumed to be subject to individual flooding when any part of the compartment is within 1.5 meters (5 feet) of the unit's waterline before damage causing flooding.

§ 108.325 Permeabilities.

The calculations submitted in accordance with § 108.329 of this subpart must show the permeability of each space considered in the calculations. The calculation of each permeability used must also be shown unless the value used is listed in Table 108.325.

TABLE 108.325—*Permeability Values*

Space	Permeability
Cargo or storage space	[1] 0.95
Accommodation space	0.95
Machinery space	0.85
Tank intended for liquid	[2] 0.0 or 0.95

[1] Actual value may be calculated and used.

[2] Use the value which results in the greatest change in the unit's waterline.

§ 108.329 Submission of damage stability data and calculations.

Damage stability data must be submitted for approval before the unit's original inspection for certification. These data must contain residual righting moment curves, wind heeling moment curves, and plans or sketches showing the unit's final equilibrium waterline, with supporting calculations for each, for each of the unit's normal operating conditions and severe storm conditions. These data must show compliance with § 108.315.

§ 108.335 Stability test.

(a) Except as provided in paragraph (c) of this section, the owner of a unit must—

(1) Conduct a stability test of the unit to determine the location of its center of gravity and lightship displacement; and

(2) Submit the results of the test for approval by the Coast Guard before the unit's original inspection for certification.[1]

(b) An authorized Coast Guard representative must be present at each stability test conducted under this section.

(c) A stability test is not required for a unit if the owner provides the Coast Guard with the Coast Guard approved results of a stability test of a sister unit and the Commandant determines that reliable stability information for the unit not tested is obtainable from the test results of the sister unit.

§ 108.337 Plans and information required at the stability test.

The owner of a unit must provide the following plans and information to the authorized Coast Guard representative prior to the stability test:

(a) Lines.

(b) Curves of form.

(c) Capacity plans showing capacities and vertical and longitudinal centers of gravity of stowage spaces and tanks.

(d) Tank sounding tables.

(e) Draft mark locations.

(f) General arrangement plan of decks, holds, and inner bottoms.

(g) Inboard and outboard profile.

(h) A complete list of material or equipment to be installed, removed, or relocated after the test, including the weight and location of each item on the list.

§ 108.339 Stability test preparations.

The following preparations must be made before conducting a stability test:

(a) The unit must be as complete as practicable at the time of the test.

(b) Each tank must be either empty and dry or full and without air pockets, except that a tank may be partially filled if the Commandant (G-MMT) determines that compliance with this requirement is impracticable and that the effect of partial filling on the location of the center of gravity and the displacement of the unit can be accurately determined.

(c) All dunnage, tools, and other items extraneous to the complete unit must be removed from the unit.

(d) The water depth at the mooring site must provide ample clearance against grounding.

(e) Each mooring line must be arranged so that it does not interfere with the free inclination of the unit during the test.

(f) The draft and axis of rotation selected for the test must be those that result in acceptable accuracy in calculating the unit's displacement and location of center of gravity.

(g) At least two weeks prior to the date of the test, a stability test procedure must be submitted for approval. The procedure must include:

(1) Identification of the unit to be tested.

(2) Date and location of the test.

(3) Inclining weight data.

(4) Pendulum locations and lengths.

(5) Approximate draft and trim of the unit.

(6) Condition of each tank.

(7) Estimated items to be installed, removed, or relocated after test, including the weight and location of each item.

(8) Schedule of events.

§ 108.341 Stability test deviation.

The authorized Coast Guard representative present at a stability test may allow a deviation from the requirement of § 108.337 of this subpart if he determines that the deviation will not affect the accuracy of the test results.

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[1] A stability letter is issued by the Coast Guard after approval of the test results and of the information required in § 109.121.

Sec.

AUTHORITY: Sec. 2, 87 Stat. 413 (46 U.S.C. 86); sec. 3, 82 Stat. 341, as amended (46 U.S.C. 367); R.S. 4406, as amended (46 U.S.C. 375); sec. 10, 35 Stat. 428 (46 U.S.C. 395); R.S. 4423, as amended (46 U.S.C. 400); R.S. 4429, as amended (46 U.S.C. 407); R.S. 4430, as amended (46 U.S.C. 408); 49 Stat. 423 (46 U.S.C. 411); R.S. 4434, as amended (46 U.S.C. 412); R.S. 4462, as amended (46 U.S.C. 416); sec. 1, 73 Stat. 475 (46 U.S.C. 481); sec. 4, 67 Stat. 462 (43 U.S.C. 1333(d)); sec. 6(b)(1), 80 Stat. 937 (49 U.S.C. 1655(b)(1)); 49 CFR 1.46(b) and (n)(6).

SOURCE: CGD 73-251, 43 FR 56808, Dec. 4, 1978, unless otherwise noted.

Subpart A—General

§ 109.101 Applicability.

No unit may be operated unless it complies with the regulations in this part.

§ 109.103 Requirements of the International Convention for Safety of Life at Sea, 1960.

No self-propelled unit of more than 500 gross tons may embark on an international voyage unless it is issued the appropriate Convention certificate as described in §§ 107.401 through 107.413 of this Subchapter.

§ 109.107 Designation of master or person in charge.

The owner of a unit or his agent shall designate an individual to be the master or person in charge of the unit.

§ 109.109 Responsibilities of master or person in charge.

(a) The master or person in charge shall:

(1) Ensure that the provisions of the Certificate of Inspection are adhered to, and

(2) Be fully cognizant of the provisions in the operating manual required by § 109.121.

(b) Nothing in this subpart shall be construed as limiting the master or person in charge, at his own responsibility, from diverting from the route prescribed in the Certificate of Inspection or taking such steps as he deems necessary and prudent to assist vessels in distress or for other emergency conditions.

§ 109.121 Operating manual.

(a) An operating manual must be prepared for each unit.

(b) Each operating manual must be approved by the Commandant (G-MMT).

(c) The operating manual must contain guidance for the safe operation of the unit under normal and emergency conditions.

(d) The operating manual must contain the following information.

(1) A general description of the unit, including lightship data.

(2) Data for each operating mode, including design loading, wave height, and draft.

(3) General arrangement showing watertight compartments, closures, vents, permanent ballast, and allowable deck loadings.

(4) Hydrostatic curves or equivalents.

(5) Capacity plan showing capacities of tanks, center of gravity, free surface corrections, and instructions for applying them.

(6) Instructions for the operation of the unit while—

(i) Preparing for the passage of a severe storm, including the specific actions and approximate length of time necessary to attain each level of preparedness; and

(ii) Change of operating condition, including preparations prior to making a move.

(7) Stability information setting forth maximum KG versus draft curve, or other parameters, based upon compliance with the intact and damaged stability criteria.

(8) Examples of loading conditions for each mode of operation, and a means for evaluation of other loading conditions.

(9) Inherent limitations of operation for each operating mode.

(10) General guidance and precautions regarding unintentional flooding.

APPENDIX E

EXCERPTS FROM CANADIAN OIL AND GAS DRILLING REGULATIONS

Standby Craft

18. (1) A suitable standby craft shall be provided for a drilling operation as a means of evacuating personnel from the drill site.

(2) The standby craft referred to in subsection (1) shall have sufficient capacity and equipment to evacuate all personnel from the drill site.

19. Every standby craft that is a vessel shall be equipped with

(*a*) approved life-rafts sufficient in number to accommodate 300 per cent of the normal complement of the standby craft;

(*b*) life jackets sufficient in number to accommodate 300 per cent of the normal complement of the standby craft;

(*c*) a minimum of

(i) four life-buoys with lines,

(ii) two climbing nets, and

(iii) four rescue hooks; and

(*d*) first aid supplies in quantities suitable for the treatment of

(i) at least ten persons having extensive second degree burns,

(ii) at least five persons having arm or leg fractures, and

(iii) at least five persons suffering from hypothermia.

Requirements for drilling units

27. (1) Every drilling unit shall be equipped with at least two enclosed powered escape capsules or survival craft or a combination of capsules and craft in sufficient number so that their combined capacity is capable of accommodating all the persons normally on board the drilling unit.

(2) Where practical, one-half of the capsules and craft referred to in subsection (1) shall be located on one side of the drilling unit and the balance of the capsules and craft shall be located on a different side of the drilling unit.

28. Every drilling unit shall be equipped with a light-weight manoeuverable power rescue boat.

29. (1) Every drilling unit shall

(*a*) be equipped with inflatable approved life-rafts in sufficient number so that their combined capacity is capable of accommodating all the persons normally on board the drilling unit;

(*b*) have an adequate means of launching all survival or lifesaving craft on the drilling unit and of embarking personnel into them;

(*c*) carry at least ten approved life-buoys;

(*d*) carry a life-jacket for each person on board the drilling unit;

(*e*) carry life-jackets at each survival craft embarkation station sufficient in number for the use of at least twenty-five per cent of the personnel capable of being accommodated on the survival craft in addition to the requirements in paragraph (*d*);

(*f*) carry a sufficient number of work vests for the use of at least fifty per cent of the persons normally on board the drilling unit at any time; and

(*g*) be equipped with a line-throwing appliance and twelve distress signals.

Meteorological Forecasts

31. (1) On the request of the Chief, an operator shall provide facilities and equipment capable of observing, measuring and recording the environmental conditions and the effect that those conditions have on the drilling operations at any drill site that is onshore or on an ice platform.

(2) Where drilling operations are carried out offshore, the operator shall

(*a*) obtain, during the period the operations are being carried out, forecasts of meteorological conditions, including ice movements, each day and each time during the day when the conditions change substantially; and

(*b*) ensure that the drilling unit is equipped with facilities and equipment for observing, measuring and recording

(i) environmental conditions, and

(ii) the pitch, roll and heave of the drilling unit.

Contingency Plans

79. (1) Every operator shall ensure that contingency plans have been formulated and that equipment is available to cope with any foreseeable emergency situation during a drilling program, including

(*a*) a serious injury to or the death of any person;

(*b*) a major fire;

(*c*) the loss of or damage to support craft,

(*d*) the loss or disablement of a drilling unit or a drilling rig;

(*e*) the loss of well control;

(*f*) arrangements for the drilling of a relief well should such become necessary,

(*g*) hazards unique to the site of the drilling operation; and

(*h*) spills of oil or other pollutants.

(2) The plans referred to in subsection (1) shall provide for coordination with any existing local or national contingency plans.

(3) A copy of the plans referred to in subsection (1) shall be

(*a*) readily accessible at each drilling rig and on each drilling unit where drilling operations are being carried out; and

(*b*) on the request of the Chief, submitted to the Chief.

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