National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation Log M-356B

Date: November 7, 1989

In reply refer to: M-89-105

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At 1605 on December 15, 1988, the 297-foot-long U.S. mobile offshore drilling unit ROWAN GORILLA I capsized and sank in the North Atlantic Ocean about 500 nautical miles southeast of Halifax, Nova Scotia, Canada. The ROWAN GORILLA I, a self-elevating type drilling rig, was being towed by the 245-foot-long Bahamian tug SMIT LONDON from Halifax to Great Yarmouth, United Kingdom when the towline broke about 0220 on December 15, during a severe storm. At 1340 on December 15, the 27 persons aboard the ROWAN GORILLA I abandoned the rig using one of the rig's survival capsules. When the rig was abandoned, there were 50-foot-high seas and the wind was blowing at about 60 knots. About 1200 on December 16, when the seas had subsided to about 15 feet in height, the 27 persons were rescued from the survival capsule by the SMIT LONDON crew. The estimated value of the rig was $90 million.[1]

For the ROWAN GORILLA I to capsize on December 15, 1988, either the rig did not have sufficient intact stability for the environmental conditions or its stability was reduced by flooding below a level capable of withstanding the overturning forces of the wind and seas. However, once the rig capsized, it would only be a matter of minutes before it sank as the result of flooding of internal compartments through ventilation openings on the main deck. To determine the cause of capsizing, the Safety Board requested that the Marathon LeTourneau Company, the designers and builders of the ROWAN GORILLA I, perform stability calculations representing the vessel and environmental conditions at the time of the capsizing. In addition, the Safety Board examined several sources of flooding before capsizing including hull structural failures, flooding through ventilation openings on the main deck, and flooding as the result of damage on the rig's main deck from loose cargo.

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[1] For more detailed information, read Marine Accident Report--"Capsizing and Sinking of the U.S. Mobile Offshore Drilling Unit ROWAN GORILLA I in the North Atlantic Ocean, December 15, 1988" (NTSB/MAR-89/06).

With its legs in the severe storm condition 25 feet below the hull, as they were at the time of capsizing, the intact ROWAN GORILLA I was designed to have sufficient stability to withstand the overturning forces imposed by a sustained wind of 100 knots during severe storm conditions provided that the rig was loaded properly. In addition, the rig was designed to withstand the overturning forces imposed by a sustained wind of 50 knots with any one compartment or tank, located within 5 feet of the exterior hull, flooded. Based on meteorological information from the rig, the tug, other vessels in the area, the National Weather Service and other meteorological sources, the Safety Board estimated that the maximum sustained wind speed at the time of capsizing to be about 60 knots. Thus, the wind speed at the time of capsize was well below the design maximum speed of 100 knots for the intact rig, but in excess of design maximum speed of 50 knots for the rig with one compartment flooded. However, the stability calculations performed by Marathon after the accident indicate that as loaded on December 15, 1988, and with both preload tanks 14 and 15 flooded, the ROWAN GORILLA I's righting moment was several times greater than the overturning moment from a 60-knot wind, and the rig would have almost no stern trim. Therefore, the Safety Board believes that the ROWAN GORILLA I, as loaded on December 15, 1988, had sufficient stability to withstand the overturning moment of the wind even with preload tanks 14 and 15 flooded.

The Safety Board next considered how much flooding would be required to reduce the rig's stability below a level at which a 60-knot wind could capsize the ROWAN GORILLA I. The rig crew testified that in addition to the water entering preload tanks 14 and 15 through hull cracks, water was entering both propulsion rooms through cracks on the main deck, water was entering the air compressor room through an opening in the main deck, and the mud pit room was flooding through an opening on the main deck whose hatch cover had been torn off by the loose container. In addition, the Safety Board assumed that water was being trapped in the shale shaker house on the rig's stern because the house was open near the top for ventilation but otherwise constructed of corrugated steel plating. The stability calculations performed by Marathon showed that with water in all the above tanks and compartments, the ROWAN GORILLA I's righting moment would still be about twice the overturning moment due to the 60-knot wind and the stern trim would be about 2^0 to 3^0. Thus, the Safety Board does not believe that the ROWAN GORILLA I would have capsized from water in preload tanks 14 and 15, the propulsion rooms, the air compressor room, the mud pit room and the shale shaker house.

About 0900 on December 15, the rig superintendent stated that the stern trim had increased from about 2^0 to 6^0 although all the equipment on deck, except for the containers which had broken loose earlier, was still in place. The Safety Board estimated that it would take a 5^0 to 6^0 stern trim for the after edge of the main deck of the ROWAN GORILLA I to be under water in still water. Therefore, with a 6^0 stern trim, the rig's after deck was now almost constantly under water. The barge engineer stated that although the crew was dewatering preload tanks 14 and 15, the stern trim continued to increase indicating to him that other after tanks must be flooding. Since both the rig superintendent and the barge engineer stated that up to the time the crew abandoned the rig, the crew was able to pump out the internal compartments as

fast as the water entered the compartments, the Safety Board believes that additional after preload tanks had to be flooding to cause the 6^{0} stern trim.

Because the ventilation openings for the after preload tanks were only about 30 inches above the main deck which was about 10 feet above the mean water level with a 2^{0} stern trim, and about 50-foot-high waves were breaking over the rig's stern, it is probable that the after preload tanks were taking on water through their ventilation openings. It is also possible that hull structural failures had occurred in additional after preload tanks resulting in their flooding. Another possible cause of flooding of after preload tanks was flooding through their 30-inch-high access hatches. The crew reported that on December 14, they had found some access hatch covers loose and had attempted to tighten all hatch covers, but could not reach those hatch covers near the stern because of the waves breaking on deck. Because the rig sank in about 16,000 feet of water and there are no plans to salvage the rig, the Safety Board was not able to examine the hull of the ROWAN GORILLA I after the sinking to determine what caused the flooding of after preload tanks. The Safety Board believes that the flooding of after preload tanks was probably due to a combination of hull structural failures, loose access hatch covers, and ventilation openings.

Once the after trim reached 6^{0}, the after main deck would be constantly under water and the ROWAN GORILLA I would rapidly loose stability. In addition, other empty tanks and compartments would begin taking on water through ventilation openings as the after main deck sank deeper into the water. When the stern trim reached 12^{0} just before the crew abandoned the rig, probably the entire main deck aft of the deckhouse was under water and all internal compartments and tanks in this area were taking on water through their main deck ventilation openings. Thus, as tanks and compartments flooded, the ROWAN GORILLA I slowly lost stability, the overturning forces of the wind and waves exceeded the righting ability of the rig, and it capsized.

The ROWAN GORILLA I was not equipped with a remote method of determining the amount of liquid in its preload tanks. The only method available to the crew of the rig was to go out on the main deck and measure the amount of liquid in each tank through either its tank sounding tube or access opening. The rig superintendent stated that from about noon on December 14 to the time they abandoned the rig, the crew was not able to safely go on deck because of the waves breaking on deck. The Safety Board believes that had the ROWAN GORILLA I been equipped with remote gauges for its preload tanks, the crew would have been able to determine that preload tanks in addition to 14 and 15 were flooding and they may have been able to repair or plug the leaks, drain those tanks, and thereby reduce the loss of freeboard and the amount of boarding seas.

Before the first hull fractures were discovered about 0730 on December 13, the rig had experienced maximum rolling of $2\ 1/2^{0}$ every 8 seconds which was well within the design limits of the legs afloat curve and a maximum wind speed of 40 knots which was well below the 100-knot design limit. During the day on December 13, the rig experienced maximum rolling of 1^{0} to $3\ 1/2^{0}$ every 8 seconds and maximum pitching of 1^{0} to $3\ 1/2^{0}$ every 8

seconds and maximum winds of 33 knots which were still well within design limits. No changes regarding the fractures in tanks 14 and 15 were reported by the crew, but about 1200 on December 13, the crew discovered cracks in welds on the support columns for the starboard leg and a crack in the structure on the inboard support column for the port leg. In anticipation of encountering a severe storm the next day, the rig superintendent at 2131 on December 13, lowered the rig legs from 12.9 feet below the hull to the severe storm position 25 feet below the hull to reduce rig motions, and at 2315 on December 13, the tug master turned the tow so that the wind and waves were on the stern of the rig.

The December 14 morning report from the rig stated that the rig was rolling 2 1/2^{0} every 7 seconds and pitching 3^{0} every 6 seconds. These motions were still well within design limits. However, about 2230 on December 14, the rig manager received a report from the rig that the maximum winds were 45 knots, the maximum waves were 20 feet high, and the rig was rolling 3 1/2^{0} to 7^{0} every 5 to 8 seconds and pitching 2^{0} to 5^{0} every 6 to 7 seconds. The rolling motion was now getting close to the design limits; however, the rig superintendent could do nothing to reduce the motions. The legs were not structurally designed to be lowered beyond the 25-foot level, and according to the tug master, a heading change under the severe weather conditions to reduce the motions would not have been possible. However, after the towline broke, the rig superintendent attempted to maneuver the rig to reduce the motions but he stated that the rig was pitching about 8^{0} every 6 to 7 seconds which was close to the design limits. At 0729, the rig superintendent reported that the maximum pitch motion had been 14^{0} every 4 to 6 seconds, which is well outside design limits, and that he had turned off the thrusters because the rig rode better without the thrusters. The Safety Board believes that because the rig motions on the evening of December 14 and on December 15 were at or above the structural design limits of the ROWAN GORILLA I, it is probable that the rig's hull experienced further hull fractures during this time. Since the crew were not able to go on deck because of the waves breaking on deck and there were no remote gauges for the periphery preload tanks, the fractures went undetected.

The hull fractures in preload tanks 14 and 15 which were discovered on the morning of December 13, before the rig experienced severe weather conditions and before the rig had the wind and waves on its stern, raise questions regarding the structural design of the rig. The ROWAN GORILLA I had sustained similar fractures in 1983 during an ocean tow when the rig experienced 50-knot winds and 9^{0} rolls. (Rowan records do not indicate the period of roll.) Marathon determined that the 1983 fractures were the result of deficient construction methods and modified the construction details, near the location where the cracks occurred, on the ROWAN GORILLA I and subsequent gorilla class MODUs. Thus, no design studies were conducted to determine if the 1983 hull fractures were the result of high stress levels.

The Marathon vice president stated that there had been no reports of hull structural failures on the ROWAN GORILLA I from 1983 until December 1988, and that he believed there was no correlation between the cracks in 1983 and the cracks in 1988. The Rowan vice president stated that because

the cracks in 1988 did not extend to the propulsion room floor as the cracks did in 1983, the construction modifications "in that area did work." The Rowan vice president testified that Rowan had made about 70 ocean tows with its self-elevating MODUs and 14 of these tows were in "North Atlantic type conditions." However, when asked to provide documentation of these trips, the Rowan vice president informed the Safety Board that the logs and other records of these transits had been destroyed.

The Safety Board believes that the 1983 and 1988 cracks are related because although the ROWAN GORILLA I was classed by ABS and certificated by the U.S. Coast Guard for ocean towing in 100-knot winds, the rig experienced hull structural failures in after preload tanks in both 1983 and 1988 when the wind speed was 50 knots or less. Both the 1983 and 1988 cracks were probably the result of stresses in the hull produced by the dynamic movement of the 504-foot-long legs in the seaway. The probable reason that the cracks did not extend to the propulsion room floor in 1988 was that the structure had been reinforced in this area after the 1983 fractures. The ROWAN GORILLA I was designed and built to ABS rules that do not require any dynamic analysis of the structure while under tow in a seaway and no dynamic analyses were ever conducted. The Safety Board believes that because the 1988 cracks occurred on December 13, when the rig motions were well within the design limits, the structural design criteria for the rig was inadequate for ocean tows.

Another concern of the Safety Board is that although the ROWAN GORILLA I legs were in the severe storm position, the rig motions on December 15, 1988, were at or above design limits with 50-knot wind speeds and the rig superintendent was not able to reduce the motions by maneuvering the rig. The ERICA observations of the December 14 and 15, 1988 storm show rapid changes in wind speed and chaotic seas which probably produced the rig motions. The Safety Board believes that the sea conditions observed during the ERICA project may account for the large motions experienced by the ROWAN GORILLA I.

The Marathon vice president stated that a dynamic structural analysis of the ROWAN GORILLA I design afloat could not be done because there are no commercially-available computer programs which can accurately and reliably predict the motions of a triangular-shaped hull with legs extended below the hull in a seaway. However, the Safety Board has determined that there are commercially-available computer programs which can be used reliably for the dynamic analysis of rigs provided the computer programs are calibrated using model tests to predict the rigs's motions in a seaway. The Safety Board believes that a dynamic structural analysis of the gorilla design can and should be conducted to determine the environmental limits of the design. In addition, the Safety Board believes that the U.S. Coast Guard, in conjunction with the ABS, needs to revise the structural design criteria for self-elevating MODUs under tow to account for dynamic loads in a seaway.

Therefore, the National Transportation Safety Board recommends that the American Bureau of Shipping:

In conjunction with the U.S. Coast Guard, revise the structural design criteria for self-elevating mobile offshore drilling units under ocean tow to include a dynamic analysis which accurately reflects rig motions expected to be encountered. (Class II, Priority Action) (M-89-105)

The National Transportation Safety Board is an independent Federal agency with the statutory responsibility "... to promote transportation safety by conducting independent accident investigations and by formulating safety improvement recommendations" (Public Law 93-633). The Safety Board is vitally interested in any action taken as a result of its safety recommendations. Therefore, it would appreciate a response from you regarding action taken or contemplated with respect to the recommendation in this letter. Please refer to Safety Recommendation M-89-105 in your reply.

Also, the Safety Board issued Safety Recommendations M-89-88 through -96 to the U.S. Coast Guard; M-89-97 through -104 to Rowan Companies, Inc.; M-89-106 to Marathon LeTourneau Offshore Company; and M-89-107 through -110 to the International Association of Drilling Contractors. The Safety Board also reiterated Safety Recommendations M-83-8 through -10 and M-87-32 to the U.S. Coast Guard and M-84-48 to the Secretary of the U.S. Department of Transportation.

KOLSTAD, Acting Chairman, and BURNETT, NALL and DICKINSON, Members, concurred in this recommendation. LAUBER, Member, did not participate.

By: James L. Kolstad
Acting Chairman