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Hurricane Ivan—Pipeline Damage, Integrity Assessment and on Bottom Stability Observations

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Abstract

The Gulf of Mexico (GoM), one of the largest sources of oil and gas production was dealt a major blow in 2004 due to hurricanes. Over the last decade it has become evident that hurricanes in the offshore GoM adversely affect life, environment and property. In September 2004, Hurricane Ivan became the ninth named storm, and the strongest hurricane of the 2004 Atlantic hurricane season. Its extreme winds and waves exceeded the 100-year storm design criteria of offshore facilities in the storm path and approximately 10,000 miles of pipelines were in the direct path of Hurricane Ivan.

A series of studies was commissioned by the Minerals Management Service of the Department of Interior (MMS) related to hurricanes and the damage to offshore oil and gas facilities. Study projects were assigned to assess the damage and to look for possible ways to mitigate such damage and associated downtime during future storm events. The focus areas of the studies are illustrated in Figure 1.

The study focuses on the cause of the failures of the pipelines. The results are presented in the form of types of failure. By analyzing the environmental conditions in the regions where the failure occurred, the impact on the design procedures are considered.

Stability analysis is performed for a few cases to correlate the actual displacement of pipelines with theoretical simulations.

Introduction

Hurricane Ivan was a long-lived hurricane that made landfall twice along the U.S. coast and reached Category 5 strength three times. Developing from a tropical wave that moved off the west

coast of Africa on August 31, 2004 and spawned a tropical depression two days later, Hurricane Ivan moved west over the next two weeks, passing near Jamaica, the Cayman Islands, and the western tip of Cuba. The storm fluctuated between Category 4 and 5 during its trek throughout the Caribbean Sea. The track of Hurricane Ivan near the shore areas is shown in Figure 2. After peaking in strength, Hurricane Ivan tracked north-northwest at a central pressure of 914 mb/140 knots (Saffir-Simpson Category 5) across the Gulf of Mexico and continued to grow weaker to 947 mb/110 knots as it made landfall near Gulf Shores-Orange Beach, Alabama.

This paper provides an overview associated with pipeline damage by determining where possible the type, cause and extent of pipeline damage that incurred during Hurricane Ivan and some discussion is given on the stability assessment of pipelines in engineering codes.

It should be noted that at the time of writing (February 2006), the study being undertaken under MMS sponsorship on Hurricane Ivan was not scheduled to be completed nor is it complete. The information contained in this paper is preliminary and subject to change. A full version of this study report will be delivered to the MMS and it will be approved and released by MMS during the course of 2006.

Damage to Pipelines

In September 2004, it was estimated that the consequence of Hurricane Ivan to Outer Continental Shelf (OCS) GoM annual production equated to 7.2% or 43.8 million barrels of oil per day (BOPD) and 3.87% or 172.3 billion standard cubic feet (BSCF) of natural gas between September 11, 2004 and February 14, 2005 (1). The transient shut in statistics during and within days after a hurricane are significantly higher as noted in Table 1. As the OCS GoM now provides 30% of the oil and 23% of the gas for domestic consumption.

In the aftermath of Hurricane Ivan it left behind widespread damage, including thousands of destroyed/damaged homes, infrastructure, beach erosion and also several miles of damaged pipelines. The strong waves and currents that Hurricane Ivan generated caused damage in a number of risers, platforms and pipelines in the GOM. The pipeline damage has been extensively reviewed and has been presented at the API conference by several industry leading operators (1). The MMS received industry assessment reports identifying damage (2) to