OTC 18313

Post Extreme Event Assessment of SCR Integrity: Strength and Fatigue Effects on the Matterhorn Gas Export SCR from Hurricane Ivan

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This paper was prepared for presentation at the 2006 Offshore Technology Conference held in Houston, Texas, U.S.A., 1–4 May 2006.

Abstract

The Matterhorn TLP (Tension Leg Platform), operated by Total E&P USA (TEP USA), was installed in 2,850ft water depth in Mississippi Canyon 243 in the Gulf of Mexico in May 2003. The TLP exports gas to shore through a 10-inch steel catenary riser (SCR), operated by TEP USA.

Within two years of installation, the Matterhorn facility has seen a Category 4 and a Category 5 hurricane pass over the facility, corresponding to wave heights in excess of the 1,000-year return conditions. This paper reports an engineering assessment of the response of the SCR to the first of these events, Hurricane Ivan, under metocean conditions measured during the storm.

The assessment of the SCR under Hurricane Ivan provides valuable insight into the hurricane response of TLP SCRs and allows this information to feed back to the design process and metocean definition.

When such extreme metocean events occur, it is essential for the operator to be aware of the impact of the storm on riser and facility integrity, in terms of proximity to design limits and effect on design fatigue life. The significance of this issue is clearly demonstrated by this paper, especially in light of recent 2005 hurricane events in the Gulf of Mexico.

Introduction

The Matterhorn TLP commenced production in the winter of 2003. The facility is located in 2,850ft of water in Mississippi Canyon (Block 243) of the Gulf of Mexico. The TLP, illustrated in Table 1, is a SeaStar® mini-TLP designed by Atlantia Offshore and is the first such TLP to produce through dry tree risers. The TLP exports gas and oil via 10-inch and 8-inch SCRs, respectively.

The gas export SCR is operated by Total E&P USA, Inc., who in 2001 contracted MCS to perform the detailed design of the riser. After SCR installation, the structural model of the SCR used for design was updated to reflect as-built, as-installed conditions by modifying the model for actual pipe weight, actual SCFs at welded joints, as-tested fatigue curve and the as-delivered flexible joint stiffness. This allowed a verification of design results and also provided an accurate model of the SCR for subsequent assessment of extreme or accidental events during service. General SCR design inputs and SCR pipe properties are presented for information in Table 1 and Table 2, while the SCR is illustrated in Figure 2.

Hurricane Ivan passed over the Matterhorn TLP on September 15th 2004. As with other facilities in the Gulf, the TLP was shut in and evacuated prior to the storm. Ivan was categorized as a Category 4 event, and the eye of the storm passed a small distance to the East of the TLP, making it one of the closest facilities in the Gulf of Mexico to the storm's path.

This paper reports the results of a post-hurricane assessment of the SCR under measured environmental conditions associated with the passage of Ivan. This work has been carried out as part of post-hurricane integrity assessment of the Matterhorn facility and risers. Wave fatigue and extreme wave effects on the strength of the SCR were key issues investigated and reported in this paper.

Hurricane Ivan Characterisation

Hurricane Ivan Overview. Figure 3 illustrates the trajectory of Hurricane Ivan as it traversed the Gulf of Mexico in September 2004.

Figure 4, which indicates the position of oil and gas production facilities near to the path of the eye of the storm, shows the location of the Matterhorn facility, approximately 40 nautical miles to the East of the storm's path.

No direct wave or TLP excursion measurements were available for the exact location of the Matterhorn facility during the passage of Ivan. However, facility horizontal accelerations were measured using accelerometers located on the hull. Calibrated hindcast data was thus required to determine metocean conditions and facility offsets during the passage of the storm.

Key Inputs for SCR Reassessment. Several challenges and uncertainties arise in hindcasting extreme wave conditions, facility motions and riser response during such a hurricane event. These include the identification of extreme maxima such as wave height and riser stress, especially the