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**Long-Term Reliability Analysis and Risk Assessment of Ultra-Deepwater  
Composite Risers**

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## 1. INTRODUCTION

Lightweight, high-strength composite risers have recently become an attractive option in developing ultra-deepwater fields. Among various technical concerns, long-term reliability is a critical issue to be addressed. Without satisfactory solutions for the issue, composite risers may not be easily qualified and accepted for use in ultra-deepwater oil and gas exploration and production (E & P), as financial and safety consequences of a riser failure are just too severe.

Long-term reliability evaluation of offshore composite riser structures requires a critical study of the inherent statistical nature of both the (material and structural) resistance (e.g., failure strength) and the deepwater environment (e.g., waves and ocean current). Ultra-deepwater composite riser design warrants special attention on experimental data, advanced concepts and computational methods for the development of riser reliability analysis and risk assessment.

The limitations of deterministic analysis and conventional design concepts, such as allowable stress design, are well known and warrant the development of a probability-based reliability analysis of the ultra-deepwater composite risers. The reliability analysis will need proper probabilistic representations of various uncertainties associated with the material system, fabrication, design and testing, including external environment loading, structural resistance, manufacturing defects, fabrication and installation variations, etc.

In this research, a comprehensive study is conducted to provide the critically needed probability-based reliability assessment methodology for proper quantitative evaluation of long-term performance of ultra-deepwater composite risers. In the

formulation and methodology development, various riser material, structure and environmental issues are addressed, including probabilistic failure of composite riser joints with statistical material strength, risk assessment of composite risers with both probabilistic loading and resistance, and effects of matrix cracking, material selection, ply layout and water depth.

The methods of approach taken in this study involve material failure modes and associated strength statistics, structure limit-state functions, and stochastic wave and current loading. In formulation of a general theory and computational methodology, mechanism-based ply failure criteria with statistical strength-life distribution functions are incorporated into a progressive failure analysis to determine time-dependent failure probability of composite riser joints from the structural limit states by Monte Carlo simulation. The long-term safety is assessed quantitatively for composite riser components and systems with both probabilistic loading and resistance.

In the following section, a brief review of literature is presented. The specific objectives to be accomplished in this research are stated in Section 3. Theoretical considerations for formulation of the reliability analysis and risk assessment of ultra-deepwater composite risers are given in Section 4. An advanced computational methodology is presented in Section 5 to determine the riser failure probability and risk. The results of several case studies are presented in Section 6. Based on the theoretical models and the computational methodology developed, and numerical results obtained, important conclusions derived from the study are given in Section 7.