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Sea Environment Assessment for Evaluation of FPSO Hull Structural Scantlings

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ABSTRACT

According to the ABS *Guide for Building and Classing Floating Production Installations* (ABS, 2009), the design criteria to reflect the site-dependent nature of a ship-type Floating Production, Storage and Offloading (FPSO) system can be accomplished through an introduction of environmental severity factors. These factors are introduced to adjust the North Atlantic unrestricted service load and fatigue damage requirements that apply to a trading vessel to the site- and route-specific service conditions for the specific FPSO installation. The two types of environmental severity factors, labeled as the α- or β-type, are defined to account for the effects of wave condition on fatigue damage and dynamic loads, respectively. To accommodate this concept, ABS has developed the Sea Environment Assessment System (SEAS) as a part of the analysis modules in the ABS Eagle FPSO software. This paper provides technical background information about the SEAS concept and its criteria for determining the environmental severity factors that are applied for the evaluation of FPSO hull structural scantling strength. The criteria that can handle complicated wave conditions in a region where both sea and swells exist simultaneously and propagate in different directions are also addressed.

KEY WORDS: SEAS; environmental severity factor; extreme load; fatigue damage; FPSO; hull scantling

INTRODUCTION

Knowledge of winds, waves, currents, tides and other environmental factors is crucial for a reliable design of a floating structure such as an FPSO. The proper sea environment assessment should be made for several sea environmental conditions pertinent to FPSOs. Depending on the FPSO type, i.e., a new build FPSO, an existing FPSO expected to move to another site or an existing tanker converting to an FPSO, it may have four different sea environment situations, i.e., intended site for operation, transit from building location to the operating site, historical sites for past operation and historical routes for operation as a tanker. Based on the proper consideration of these environmental conditions, a rational structural assessment for evaluation of FPSO hull strength and fatigue capacity is demanded to provide the necessary structural integrity throughout its service life. For this purpose, the environmental condition is defined with a specific combination of wind, waves and current for which the subject FPSO is to be designed.

In general, the FPSO structural design and analysis criteria are applied in two phases. The first phase provides the basic hull design to reflect overall hull girder and local structural component strength, including fatigue strength. This is referred to as the Initial Scantling Evaluation (ISE) phase. For FPSO conversions, the reassessed and renewal scantlings are calculated in the ISE phase. The reassessed scantlings are the required scantlings for the site-specific location and transit condition, and are used to establish the minimum renewal scantlings of an FPSO conversion. The second phase requires the performance of finite element structural analyses using either a three cargo tank-length model or cargo block-length model to validate the selected scantlings from the first phase. This is referred to as the Total Strength Assessment (TSA) phase. For ship-type conversions, the TSA phase is used to validate the reassessed scantlings obtained in the ISE phase.

To accomplish the design goal through the ISE and TSA phases, it is necessary to evaluate extreme dynamic loads and fatigue damages exerted from the environmentally induced responses. For this, ABS applies the SEAS program, especially for FPSO applications. In SEAS, there are two types of environmental severity factors (ESFs) labeled as being of the α- or β-type. The α-factors are used to adjust fatigue strength performance expectations between the unrestricted environment service and the long-term site-specific environment, and to estimate the accumulated fatigue damage which occurred during the historical service. The β-factors are used primarily to adjust the dynamic components of loads used in the strength analyses of the hull, and ancillary forces, such as those from the motion of equipment masses located on or above the main deck.

The SEAS program is one of the modules in the ABS Eagle FPSO software that is used to evaluate hull scantlings during the strength and fatigue assessment. Figure 1 depicts SEAS as an integrated module of the ABS Eagle FPSO software. In summary, SEAS can be used in the determination of:

- The β-type ESFs, which are to modify dominant load parameters on an FPSO at an intended site and a transit route for strength check (both ISE and TSA); in this regard, should it be necessary to perform a fatigue assessment of hull structural details using the structural