17 Collisions of Ships with Offshore Wind Turbines: Calculation and Risk Evaluation

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17.1 Introduction

Collisions of ships with offshore wind energy turbines (OWTs) constitute a considerable threat to the environment. It must be considered that in a collision incident, parts of the ship's structure will be damaged. Leakage of operating supply or cargo (e. g. oil or chemicals) is possible. In a worst case scenario the ship could break apart and sink.

The research project referred to in this paper undertook a numerical evaluation of several collision scenarios between different ship types and three exemplary types of foundation structure. The resulting conclusions were supposed to lead to an evaluative scheme to determine the mechanical properties of OWT foundation structures concerning their crashworthiness and their ability to conserve hull integrity in ship collisions. These guidelines shall be used in the process of the approval of OWTs.

A stochastic analysis of the probability of collisions was not the goal of the project, although it is necessary to link both an analysis concerning the probability of a collision and a consequence analysis, to determine the risk.

In an analysis done by the Federal Environmental Agency (UBA) on preventive action in the event of a failure in offshore wind farms, a single hull oil-tanker of 160,000 tdw was proposed to be the design ship in the accidental limit state (ALS). Also, a damage of three cargo tanks was estimated as likely, which assumed 54,400 tons of spilled oil as the basis for calculating necessary preventive action (Kremser 2004).

If the mechanical performance of OWTs in case of collision is known, the probability of environmental damage can be estimated, depending on the particular conditions. This leads to a more favourable evaluation of environmental risk than has hitherto been possible. This especially takes into account the increase in passive safety measures against collisions. To provide maximum safety, provisions for active collision and fault event safety, such as redundant navigation and control systems, a ban on navigation for certain kinds of ships, crew training, traffic management systems, wind farm monitoring, tug boats for emergencies, etc.) must be considered in order to prevent collisions and emergency situations before they occur.

17.2 Technical Bases and Numerical Modelling

17.2.1 Collision of Ships

The aspect of collision safety is mostly treated in connection with the construction of tankers. For this type of vessels, there is an international binding agreement (MARPOL 73/78 Annex I, Directive 13F), which determines the minimum dimensions of double bottoms and double hulls. According to the design specifications of Germanischer Lloyd (2002), an extra class index (COLL) can be achieved, if there is calculatory evidence for heightened safety in collisions.

The standard of knowledge and the methods of simulating collision and grounding events were enhanced by scientific projects, which were initiated by the spectacular tanker wrecks of "Exxon Valdez" and "Braer" and set forth e.g. in connection with the construction of the Great-Belt-Crossing. In these projects, empirical, analytical, and numerical methods were applied and many experiments were executed. Several experiments and analyses are described in the dissertation by Zhang (1999), which also features an extensive reading list on the field of collision analysis.

With the aid and the enhancement of these methods and findings, this institute carried out two projects between 1995 and 1999 which dealt with the safety of double hull tankers in instances of collision and grounding (Kulzep and Peschmann 1998 and 1999). Apart from this, there is a worldwide interest in the limitation of risks of collision. An overview of the current situation can be found in the technical literature, especially in the ICCGS-Conference Proceedings[1].

17.2.2 Foundation Structures of Offshore Wind Energy Turbines

The OWTs considered in this study are designed with steel pile foundations[2]. Wiemann et al. (2002) give a survey of explorations and analysis of the foundation soil in the designated area and of methods for the design of

[1] International Conference on Collision and Grounding of Ships; July 2001 in Copenhagen; October 2004 in Tokyo

[2] The state of the art is documented by the presently valid German and international standards (DIN 1054; DIN 4014; DIN 4026; EAU 1999; American Petroleum Institute 1993; Germanischer Lloyd WindEnergy GmbH 1999; Det Norske Veritas Classification A/S 1992).