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Floating Production Platform for Polar Seas Designed to Resist Iceberg Impact

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ABSTRACT

Nowadays selection of ice-resistant platform for middle sea depth (from 200 to 400 m) is a vital problem for development of the Russian shelf (the Barents Sea, Sakhalin, etc.).
According to the previous analysis the cost efficient way is to use a floating substructure like TLP, SPAR or Semi-submersible.
However, traditionally mentioned above platforms are considered as non-suitable for ice conditions due to their unacceptable behaviour against ice impact. In the same time TLP and SPAR type substructures are considered for operation in ice conditions but shall have mooring (anchoring) system specially designed to withstand the ice impacts. Specifically actual problem for Shtokman field (the Barents Sea) is drifting icebergs that cause highest risks for the platform safety. SPAR type substructure with only flexible risers may be treated as an acceptable construction even in case of iceberg impact risks – provided certain innovations are implemented – and this is the subject of this paper.
The paper provides comparison of various mooring systems for SPAR platforms and assessment of the ultimate resistance of the mooring system against global iceberg impact (or a huge grounded hummock) depending on its weigh and drifting speed.

KEY WORDS: platform floating substructure, floating stability, ice force, iceberg, ice ridges (floating grounded hummock), iceberg drifting speed, iceberg energy, platform displacement parameters, mooring system, computer simulation.

INTRODUCTION

It is assumed that influence of an iceberg on a floating moored platform is irresistible. In case of iceberg threat the iceberg physical management- preventing iceberg from permeating into the near-field area or contacting with the facility (G. Crocker et al, 1998) is carried out. If there is no such possibility or in case of unsuccessful outcome of the operation for iceberg withdrawal the following urgent measures shall be taken in order to reduce risks of such contact consequence: for FPSO – disconnection risers and mooring lines from the turret, for Spar – disconnection of special seabed riser and mooring line unit. Even in case of successful disconnection operation the reconnection is intensive and dangerous operation and may take some months.
At the same time, it may be presumed that contact of Spar type facility with an iceberg of limited size and weight may prove to be conditionally safe for the facility and would not require any emergency actions. Thus, the actual task is to determine limits for dimensions, weight and drifting speed of the iceberg, at which the above stated the emergency prevention actions are not necessary. Moreover, the mooring system may be designed such to increase its ability to resist iceberg impact.
This paper presents a concept of Spar-type floating substructure equipped with a mooring system designed to resist both ice impact from floes and iceberg impact. Sufficient resistance of the proposed mooring system options against ice/iceberg is ensured by configuration and geometrical arrangement of mooring lines taking into account the limited (for Spar concept) sea depth.
The proposed mooring system design is aimed at the following:

1. To compensate for the static component of forces caused by impact of ice floe including hummocks directly contacting the Spar column ice belt;
2. To absorb kinetic energy of drifting iceberg by means of increase of potential energy in mooring line tensioning;
3. To reduce the local dynamic load from an ice floe or iceberg by gradual growth of contact force due to flexibility and damping properties of the mooring system design.

Satisfactory operation of the mooring system designed for the mentioned purposes is maintained by the appropriate floating column structure that shall ensure the following:

1) sufficient excess buoyancy for satisfactory tension of the mooring lines in order to restrict the platform displacements caused by ice/iceberg;

2) required stability in order to withstand the overturning moment.

Ability of the proposed mooring system and Spar-type substructure to compensate for the global ice load under ice/iceberg impact may be evaluated by means of a quasi-static analysis of energy-absorbing properties of the mooring system together with the column and my be checked by computer simulation of dynamic iceberg-platform interaction.
Environmental conditions including iceberg statistics, were assumed for the eastern part of the Barents Sea based on information received from Russian Arctic&Antarctic Institute (AARI) (Zubakin et al, 2006).
The present paper covers development of a mooring system able to resist against floe/icebergs, determination of requirements for the floating column designed to ensure operation of the mooring system, assessment of their behaviour under iceberg impact, specification and validation of fulfilment of safety criteria.