Squall in Mid-latitude Regions and its Effect on Offshore Operations

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ABSTRACT

Squall can bring a sudden change of wind speed in a few minute with wind direction changing rapidly at the same time up to 180 degrees. The purpose of this study is to investigate the possible occurrence of the squall especially the one caused by squall line in mid-latitude ocean development areas, to clarify the site-specific characteristics of the squall for each field. At last, the simulation models of squall, that is time varied wind conditions, are proposed temporarily to demonstrate the influence of squall on the safety of floating structures, such as station keeping ship with DPS.

KEY WORDS: Squall; squall line; mid-latitude; wind; sudden change; offshore operations; DPS.

INTRODUCTION

The sudden increase of wind speed called “squall” has become increasingly concerned nowadays. According to the World Meteorological Organization (WMO), the definition of the squall is a sudden increase of wind speed of at least 8 m/s, the speed rising to 11 m/s or more, and lasting for at least one minute. Besides the increase of wind speed, the wind direction often changes rapidly at the same time up to 180 degrees. In West Africa, the cumulonimbi are formed easily in Inter-tropical Convergence Zone. Adding the effect of the humid maritime air from the Gulf of Guinea and the dry continental air originating over the Sahara, the frequent generated squall is an important factor to design the mooring system for floating units (Legerstee, François, Morandini and Le-Guennec, 2006; Peters and Tetzlaff, 1988).

It is well known meteorologically that squall also happens in mid-latitude regions, such as Southern United States and Japan, and some serious incidents on land have been reported (Jeans, Cooper, Yetsko and Bryan, 2014). But in contrast to other severe weather such as hurricane, typhoon and winter storms, squalls are considered to be less powerful and not so influential for designing offshore structures. However, strong squall will not only destroy structures but cause accidents in operations because of its distinguished features; sudden speed increases and wind direction changes at large angles.

In this study, squall in mid-latitude regions, especially the one caused by pre-frontal squall line (Fig.1) are emphasized, including the Northern Hemisphere - Japan, the Southern United States and the Southern Hemisphere – the Southern Brazil. The purpose of this study is to investigate the possible occurrence of the squall in these places, and to clarify the site-specific characteristics of the squall for each field.

At last, depending on the squalls in the sea near Japan searched by analyzing the data from remote islands, the simulation models of squall, that is time varied wind conditions, are temporarily proposed to demonstrate the influence of squall on the safety of floating structures, such as station keeping ship with dynamic positioning system (DPS). Finally, simulations are carried out to evaluate the effect of squall event on offshore operations.

Fig.1 The Pre-frontal squall line

METEOROLOGY IN MID-LATITUDES

Weather changes suddenly and dramatically are the distinguishing feature of mid-latitude weather. And the passage of weather fronts are the principal contributor to these changes (Lutgens, Tarbuck and Tusa, 2001). Thus, in order to investigate the sudden change of wind condition – squall, it is crucial to understand the meteorological environment for front development.

Squall and Squall Line

According to the World Meteorological Organization (WMO), when wind speed increase at least 8m/s, and sustain over 11 m/s or more for