Marine

FORECASTING OF SUPERSTRUCTURE ICING FOR ALASKAN WATERS*

David M. Feit (1)
NOAA/NWS
Ocean Products Center
Camp Springs, MD

ABSTRACT

Methods available for determining the potential for forming ice on ship superstructures are summarized. The National Meteorological Center (NMC) ice accretion forecast system is described and two ice accretion forecast techniques, Overland et al and Wise and Comisky, are evaluated using observations taken in the Alaskan waters. The results of the evaluation indicate that the Overland et al technique is superior.

1. INTRODUCTION

Marine weather at high latitudes is associated with a number of problems unique to the cold regions of the globe. Among these is the hazard created by the conditions of sub-freezing air temperatures combined with strong winds and sea temperatures near freezing. This hazard is called superstructure ice accretion and is defined as the accumulation of ice formed on exposed structural components of ships or structures above the water surface either on the coast or at sea. Advising marine interests of the existence and expected location and intensity of ice accretion is important for both the safety of the vessel and its efficiency of operation.

The accumulation of ice on small vessels has the potential of causing serious handling problems leading to instability and, ultimately, capsizing. This is particularly true of fishing trawlers which may have tons of fish and water shifting about in their holds. There are numerous instances of loss of life at sea directly or indirectly attributable to icing problems. To cite a couple of examples, Shekhtman (2) notes the loss, in the Bering Sea on 19 January 1965, of 10 Soviet vessels due to instability brought on by the accumulation of ice. On 14 January 1980, two of five hands were lost aboard a crabber, the Gemini, when it capsized off the Alaskan coast due to icing induced instability.

The extra weight of ice on masts and rigging not only makes the vessel top heavy but also increases its "sail area," thereby creating difficulties in handling due to the effect of winds. Although the result of such increased windage is not likely to be as disastrous as instability, it is a situation to be avoided.

While larger ships have less of a problem with ice induced instability, they are not immune. The accumulation of ice on antennae makes radio communication difficult if not impossible (3). On all sizes of vessels ice accumulation results in hazardous working conditions on deck. During fishing operations the ability to work with deck equipment in an unhampered manner is of prime importance. Ice accretion, of course, impedes the efficient use of deck equipment and slows the work. Cargo vessels, particularly container ships, may find that upon reaching the destination port, the deck cargo is ice encrusted to the point where unloading is impossible, even though the vessel is safely berthed, resulting in costly delays.

A major obstacle to the development of improved forecast techniques is the lack of accurate and consistent observations from vessels at sea. This is not surprising since ice accretion rates and amounts are greatly affected by such factors as the size and shape of the ship's hull and superstructure, the heading of the vessel relative to the wind and the sea keeping ability of the ship. An example of the type of data needed to permit a full description of the problem may be found in Minsk (4). He reports on objectively measuring ice accretion by exposing an array of cylinders mounted on a drilling rig in the North Aleutian shelf to freezing spray and weighing and profiling the ice at regular intervals. Clearly, this is not appropriate for obtaining observations from commercial vessels.

A number of authors have reviewed the various aspects involved in the icing of the ocean structures. Among them Makkonen (5), Lozowski and Gates (6) and Jessup (7). The reader is encouraged to refer to these papers for a more general view of the subject. The purpose of this paper is to describe the method adopted by the National Meteorological Center (NMC) to produce automated ice accretion guidance forecasts from information available through operational numerical weather prediction models.

2. SOURCES OF ICE ACCRETION

Among the various causes of ice accretion on ships, the most common are fog, freezing rain, snowfall and freezing spray. The relative importance of these factors is discussed below.

In the marine environment two types of fog occur most frequently. The first, advection fog, is not an expected source of icing since it is formed when warm air flows over cold water and the air temperature can be expected to be above freezing in virtually all cases. The second, sea smoke, although not a common cause of icing, cannot be disregarded as a source. Sea smoke ranges in thickness from a few meters to several hundred. It occurs when very cold air flows over substantially warmer water. The process for forming ice may be summarized as follows: Relatively warm water evaporates at the surface but condenses into droplets again as it is convectively transported into the colder air. If this overlying air is very much below freezing the droplets will be supercooled and freeze upon impact with the ship. An example of an extreme case is described by Lee (8) in which a vessel traveling through sea smoke (visibility 200 yds) picked up approximately 26 tons of ice in 10 hours.

Another atmospheric source of ice accretion is freezing precipitation. This occurs in the form of rain or drizzle. Its effect is to glaze the ships surface with a clear hard coating of ice. This type of icing is not considered serious because the accumulated weight tends to remain relatively low and the handling properties of the ship due to increased sail area are not significantly affected. On the other hand the glaze may affect communications and impede the work of deck hands. Precipitation in the form of snow plays a minimal role as a source of ice accretion since most of it generally tends to blow off the ship. The remaining snow is usually not very dense and adds little to the accumulated weight and sail area.

Finally, the most important of the causative factors is freezing spray. Freezing spray is a result of either the action of the wind on the water or the impact of the ship against the waves. In both cases the spray is carried by the wind and exchanges heat with the cooler air. The temperature ultimately reached by the spray is dependent upon the ambient temperature, the amount of time it is being transported, the initial temperature of the spray and the initial size of the spray droplets.

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