ICEBERG AND SEA ICE HAZARDS

Icebergs pose a serious threat to navigation and oil and gas operations off Canada’s East Coast. For shipping companies, offshore operators, and the associated regulatory bodies, the presence of icebergs necessitates many safety precautions and considerations. Reconnaissance flights are carried out by Environment Canada and the International Ice Panel to locate icebergs over the North Atlantic, but this is only part of the required response. Forecasting the drift paths of icebergs is essential for safe travel, shipping and oil drilling operations. The NRC Iceberg Drift Forecasting Model is used to predict the tracks of icebergs in the vicinity of offshore oil operations on the Grand Banks. NRC has also created three Iceberg Engineering Databases to provide key data on icebergs and iceberg ice, iceberg management events, and iceberg shapes. These databases are a repository of information that can be used for planning of offshore operations.

Sea ice is also an important consideration for offshore operations in many Canadian regions. Environmental forces can drive the ice cover to compact and ridge, causing ice convergence or pressure. If a ship becomes beset or stuck in pressured ice many concerns arise, including the health and safety of the crew, the increasing cost of operations and the risk of adverse environmental effects. The NRC Vessel Besetting Database contains a wealth of information on ships beset or damaged by pressured ice. Forecasting the drift of pack ice and ice pressure build-up, predicting the risk of a vessel besetting, and quantifying ice pressure depositions are all essential for safe and efficient operations in northern waters. The forecasting of ice drift and pressure has to be carried out on a scale relevant to shipping and offshore drilling operations. For this purpose, NRC has created the Pressured Ice Model.

NRC ICEBERG DRIFT FORECASTING MODEL

By the late 1990s, the Canadian Ice Service (CIS) identified the need for a new forecasting model that could meet the demands of modern operations. The model undertakes a research effort aimed at developing a reliable iceberg drift model in collaboration with CIS, academia and private consultants.

NRC’s Iceberg Drift Model incorporates comprehensive physics of iceberg motion, deformation and calving, as well as a robust numerical method. The model development has included extensive collaboration with industry to ensure proper validation of model predictions and observations.

Requirements of the end users were of paramount significance at each stage of the development. Today, the model is used by meteorological agencies that issue iceberg forecasts including CIS, the International Ice Patrol (IIP), and the Norwegian Meteorological Agency. CIS has customized the model to suit the needs of offshore operators. For example, the model is licensed to Provincial Aerospace Ltd. (PAL), global leaders in airborne maritime surveillance. PAL has been successfully integrating the model into their business for several years to support the iceberg towing operations that protect the oil drilling platforms on the Grand Banks.

Collaborating with clients and partners, NRC continues to develop and enhance the Iceberg Drift Model to meet the needs of the offshore and shipping industries.

NRC PERD ICEBERG ENGINEERING DATABASES

In the early days of oil and gas development on the Grand Banks, each petroleum company collected and managed its own iceberg data sets and the data were scattered and isolated. NRC, with the support of the Program of Energy Research and Development (PERD), has been working with offshore regulators to develop industry standard databases on key iceberg information. NRC has maintained and updated these databases to help with the ongoing need for easily accessing new data.

Iceberg Sightings Database

The NRC-PERD Iceberg Sightings Database is the result of a major effort to collect visual and radar-detected iceberg sightings from ships, aircraft, offshore structures and satellite from the past 400 years. Current data is added at the end of each ice season. Information from the IIP makes up a large part of the database; aircraft sightings data are available since 1941, and regular iceberg sightings began in 1960. Data from the Grand Banks oil operators have been collected since 1973. In more recent years, satellite data have become available. A considerable effort was made to preserve historic iceberg sightings data from sporadic ship-ice collision and other reports dating back to the 1800s, along with more frequent sightings reported since the 1800s. The database includes the source, date and time of sightings, geographic coordinates, and iceberg shape and size categories (with dimensions if available). A total of over 400,000 iceberg sightings are included, of which about 100,000 are confirmed re-sights (same iceberg tracked more than once). The Iceberg Sightings Database has become the industry standard for historic iceberg sightings off eastern Canada.

Iceberg Management Database

Iceberg management operations have been documented since the 1970s and are now a routine part of oil and gas development operations offshore Newfoundland and Labrador. The NRC-PERD Iceberg Management Database is an extensive compilation of records of iceberg management operations, bringing together information from numerous oil and gas exploration and development companies. It contains over 1,800 records of iceberg management operations concentrated in the Grand Banks and offshore Labrador, with one year of data from West Greenland. The database includes parameters such as iceberg size and shape, management methods/is used, and iceberg trajectory information and photos.

NRC VESSEL BESETTING DATABASE

A database documenting cases of ship besetting in Canadian waters has been created by NRC from the compilation and analysis of over 1,700 reports of ship entanglement or damage in pressured or ridged ice conditions. This work was funded in part by PERD and Transport Canada. The database includes information on the time and location of the event, vessel characteristics, and details of the ice conditions and environmental conditions that led to the ship besetting. A snapshot of the locations of reported incidents as of 2014 is shown in Figure 2. Most reported cases occurred over the Gulf of St. Lawrence, likely due to the high frequency of shipping over this area. The Vessel Besetting Database is updated regularly as new reports become available.

NRC PRESSURED ICE AND PACK ICE DRIFT FORECASTING MODEL

Pressured ice conditions arise when environmental forces cause the convergence of ice, creating dangerous build-ups. NRC’s research on this topic is aimed at developing specific characteristics of pressured ice, and quantifying the ability of ships to navigate in such conditions. The result of this research, the Pressured Ice Model, is now being used successfully by organizations that have major operations in the Canadian Arctic and North Atlantic waters.

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Ocean, Coastal and River Engineering

Canadian Research Council

CIS and PERD: Iceberg Engineering Databases

Overview of NRC Sea Ice and Iceberg Forecasting and Engineering Tools

The UMBK, an icebreaking bulk carrier, was beset in pressured ice off the Labrador Coast for 10 days in June 2007. Photo contributed by Tim Keane, Fisheries.

The Pressured Ice Model is used by ship owners and operators, offshore platform operators, and ship captains to enhance the safety and efficiency of navigation in severe ice. It has been implemented at the Canadian Coast Guard regional office in St. John’s, NL, licensed for use by a large petroleum operator and licensed for training at the Fisheries and Marine Institute of Memorial University, NL. In addition, forecasts generated by the model have been provided to CIS for the regions of the Gulf of St. Lawrence, Strait of Belle Isle and the Newfoundland Coast.

The complexity of dealing with problems of navigation in sea ice arises, to a large extent, because of scale effects. The distinction of ice covers and associated stresses vary according to the scale under consideration. Larger-scale forecasts based on ice dynamics models and analyses of remote sensing imagery can resolve ice deformation processes over lengths of a few kilometers. Ships, however, experience different modes of ice deformation (e.g. riding and lead opening) and different stress levels. This discrepancy limits the value of many ice forecasting products to evaluate the threat of pressured ice conditions to navigation.

The Pressured Ice Model deals with ice dynamics on a scale relevant to a vessel. The numerical solution is based on a hybrid Lagrangian-Eulerian formulation and an implicit finite-difference solver. It considers appropriate physics of ice properties and high-resolution deformation processes including riding and lead opening. It predicts jamming and arch formation in narrow channels, such as those of the Canadian Arctic archipelago. Maps created by the model demonstrate the evolution of ice thickness, concentration, pressure build-up and ridging. This allows for the prediction of ice movement and dynamics, and most importantly, regions of pressured ice conditions. The tool is unique in that it allows the input of local conditions, making the display of information more reliable and decreasing the risk of vessel besetting. The model is continuously enhanced to incorporate feedback from end users.

Example of Pressured Ice Model forecast. Ice concentration is shown over the Grand Banks region. Black indicates water current, and barbs indicate wind.