

RINA

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International Conference on
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ICE CLASS VESSELS

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WESTIN CHOSUN HOTEL, BUSAN, KOREA

Vast reserves of oil and gas are expected to be exploited in the Russian Arctic, including the Barents Sea, the Pechora Sea and Kara Sea. There are also new gas fields being developed on the Yamal Peninsula. There is a need for large tankers, LNG carriers and associated support vessels to transport the oil and gas and maintain operations in these far northern locations. Increasing numbers of passenger ships are also operating in low temperature environments.

Vessels operating in the Arctic regions are exposed to a number of unique demands. The pressure of first year and multi year ice imposes additional loads on the hull, propulsion system and appendages. New designs have evolved such as the Double-acting principle. The extreme environmental conditions can also have significant effects on vessel systems and machinery.

Low temperatures and poor visibility can have profound effects on the crew and vessel operations. Current operational experience in the Arctic is limited to much smaller vessels than those that are envisaged. There is great probability that new owners and operators without operational experience in these harsh conditions will enter the market. This will impose a need for guidance for these owners and operators, as well as shipyards building vessels for cold weather service.

day 1

09.00 - 09.30 COFFEE AND REGISTRATION

09.30 - 10.00 KEYNOTE ADDRESS

10.00 - 10.35 ON THE DEVELOPMENT OF TRANSPOLAR TRADING CARGO VESSELS
M. Niini, Aker Arctic Technology Inc., FINLAND
Robert Tustin, Lloyd's Register Asia, SOUTH KOREA

The paper will consider transpolar trade routes from a historical perspective of such operations, as well as, recent scenarios for such trades. An overview will be offered of the expected ice conditions for transpolar voyages as well as how these ice conditions could influence the development of trade routes. These design concepts will be compared with the existing Polar cargo vessel fleet. Regulatory and legislative issues for future transpolar shipping will be outlined. Specific consideration will be given to the impact of existing and planned environmental protection legislation at IMO.

10.35 - 11.05 COFFEE

11.05 - 11.40 COMPARATIVE STUDY OF RESISTANCE PERFORMANCE WITH REFRIGERATED ICE AND WITH SYNTHETIC ICE ACCORDING TO VARIATION OF HULL FORM
Moon Chan Kim, Pusan National University, SOUTH KOREA

The present paper deals with the comparative study of resistance performance with refrigerated ice and synthetic ice according to the variation of hull form characteristics. The resistance test has been conducted in pack ice condition according to the variation of concentration rate. Stem angle has been chosen as main parameters for the variation of hull form characteristics. The correlation of performance between with the refrigerated ice conducted in IOT ice tank and with the synthetic ice has been shown according to the variation of stem angles.

11.40 - 12.15 NUMERICAL PREDICTION FOR RESISTANCE OF CANADIAN ICEBREAKER CCGS TERRY FOX IN LEVEL ICE
Jungyong Wang, National Research Council Canada, Institute for Ocean Technology, CANADA

The aim of this paper is to present numerical prediction results for an icebreaker resistance in level ice. Two commercial finite element codes (ANSYS and LS-DYNA) are used. In LS-DYNA, a user-defined material routine is used to simulate ice: a multi-surface failure criterion is implemented and ice behaves as a linear elastic material before a failure occurs. Numerical results are then compared to full-scale measurement results.

12.15 - 13.15 LUNCH

13.15 - 13.50 PREDICTING PACK ICE LOADS ON MOORED VESSELS
Don Spencer & David Molyneux, Oceanic Consulting Corporation, CANADA

Drill ships and Floating Production Storage and Offloading units used for the production of oil and gas are required to operate in waters covered in broken ice, which will vary in the percentage coverage of the sea surface. One practical option for keeping the vessel on station is a moored system which allows the hull to rotate about a turret within the ship. Predicting the loads acting on the hull due to pack ice is an important step in developing the design of the hull and the mooring system. This paper presents equations for predicting the loads on the hull due to pack ice.

13.50 - 14.25 GLOBAL ICE LOAD ESTIMATION ON ICEBREAKING VESSELS UNDER NORMAL OPERATING CONDITIONS
Kyungsik Choi, Korea Maritime University, SOUTH KOREA

In this paper, the design ice load prediction for the icebreaking vessels under normal operating condition in ice-covered sea is discussed. The ice loads under normal operating condition are expected from regular sea trials in moderate ice conditions. Current study describes the

global ice load on the hull of the icebreaking vessels. Available ice load data from full-scale sea trials are collected and analyzed according to various ship-ice interaction parameters including displacement, stem angle, speed of a ship and flexural strength and thickness of sea ice. The ice load prediction formula is compared with the collected full-scale sea trials data and it shows a good agreement.

14.25 - 15.00 LEARNING FROM ICE DAMAGE INVESTIGATIONS FOR FUTURE ARCTIC SHIPS
Erkki Ranki, Aker Arctic Technology, FINLAND
Rob Hindley, Lloyd's Register, SOUTH KOREA

This paper describes the methods, approaches and learning from ice damage investigations by Aker Arctic Technology and Lloyd's Register to support future Arctic ship developments. The paper describes a series of studies undertaken by Aker Arctic Technology to evaluate recorded hull damage due to ice experienced in stern and aft shoulder areas. An overview of the analysis methods and ice pressures associated with the damage cases is given. The paper concludes with a review of how the analysis work is to be adopted by Lloyd's Register for the Classification of future Arctic Ships.

15.00 - 15.30 COFFEE

15.30 - 16.05 ICE LOAD MONITORING SYSTEM FOR LARGE ARCTIC SHUTTLE TANKER
Jaewoong Choi, Gunil Park, Youngsung Kim, and Munkeun Ha, Samsung Heavy Industries, SOUTH KOREA
Han Yu, ABS, SOUTH KOREA
Alex Iyerusalimskiy, ConocoPhillips
Jim St. John, STC

According to recent Arctic resource development, there are needs for ice breaking merchant vessels which have high ice breaking capability and can independently navigate year round in the Arctic Ocean. For the structural integrity of the vessels is highly important, structural damage from ice load during ice navigation should be avoided and minimized. This paper introduces a systematic approach to design, install, calibrate and commission the system that composes of fiber optic sensors and relating signal processing modules.

16.05 - 16.40 ASSESSMENT OF ICE LOADS ON STERN REGIONS OF ICE CLASS SHIPS
C Daley, Memorial University, CANADA
H Yu, American Bureau of Shipping, USA

New ships will need to be able to travel in heavy ice beyond any current experience, posing challenges for both hull and machinery design. The paper presents additional methods for assessing risk to Arctic ships in a variety of scenarios. One is the case of a large ship striking heavy ice while operating astern. The second is a collision between a submerged ice floe and a pod propulsion housing. The paper provides owners/designers/regulators with examples from realistic vessels of a methodology to examine ice loads using a rational set of design scenarios.

16.40 - 17.15 GUIDANCE NOTES FOR THE CLASSIFICATION OF STERN FIRST ICE CLASS SHIPS
Rob Hindley and Rob Tustin, Lloyd's Register, SOUTH KOREA

Recent orders for ice going ships have indicated an increased trend in the use of podded propulsion systems and azimuthing thrusters for ships navigating in ice. One of the unique capabilities of these ships is the ability to operate in heavy ice astern, or "Stern First" through rotating the propulsion unit 180 degrees. Lloyd's Register has developed guidance notes to ensure a consistent approach to the interpretation of requirements for classification and to assist designers in developing "Stern First" ice class ships. The paper concludes with details of the process for validating the guidance notes.

17.15 - 17.30 GENERAL DISCUSSION

17.30 - EVENING DRINKS RECEPTION

Following the conference on 30/09/09 we are hoping to give delegates the opportunity to visit the nearby Hanjin shipyard to view the recently built KORDI ice classed research vessel prior to its official launch. If you would like to join this visit please tick the appropriate box overleaf when returning the registration form and full details will be sent to you when we have them.

day 2

09.00 - 09.30 COFFEE AND REGISTRATION

09.30 - 10.00 SHAFT AND BLADE LOADING CHARACTERISTICS OF AN ICE CLASS PODDED PROPELLER UNDER ICE INTERACTION

Pengfei Liu, National Research Council, CANADA

Interaction between an ice sheet on the water surface and an approaching podded R-Class propeller unit was examined and analyzed using an unsteady time-domain multiple-object panel method. In addition to a comparison analysis based on a recent in-house experimental set up for an ice sheet and an approaching ice class podded propeller unit, the numerical model was also checked against various previous in-house experimental measurements. The code was also used to predict blade root section's spindle, in-plane and out-of-plane bending moments. Force fluctuations of the spindle torque and the two bending moments at the blade root section were also presented and analyzed.

10.00 - 10.35 LNG MEMBRANE COLLISION SIMULATIONS AND ASSESSMENT

PAIK Jeom Kee, Pusan National University, SOUTH KOREA
LEE Sang-Gab, LEE Jae-Seok and BAEK Yun-Hwa, Korea Maritime University, SOUTH KOREA

There have been demands for the security of design technique of Arctic LNG carrier, especially for the structural safety assessment of the Arctic LNG CCS (Cargo Containment System) under the impact of collision with iceberg. Possible iceberg sizes and shapes in Arctic and sub-Arctic routes of LNG carriers were investigated and diverse scenarios of full scale iceberg-ship bow shoulder collision simulations with consideration of surrounding sea water were carried out for the development of more accurate and realistic collision analysis technique and the examination of their effects on the collision responses using LS-DYNA code : analysis techniques FSI and MCOL, elastic and ice type iceberg materials, iceberg shape, iceberg size, attack angle, LNG carrier speed and inner fluid.

10.35 - 11.05 COFFEE

11.05 - 11.40 NUMERICAL MODELING THE COLLISION OF AN ICEBERG WITH A SPAR

Don Spencer, Oceanic Consulting Corp.
John Murray, FloaTEC LLC

To ascertain the expected loading on one concept, the Spar, numerical simulations were made using DECICE3D. DECICE is a time domain discrete element modeling tool specially designed for ice related engineering. Modifications were made to the code to allow for the Spar's mooring system. The ice crushing pressure in the contact zone was assumed to be a function of the contact area. Simulations were made for three differing size iceberg, each having a different maximum impact velocity. Output of the simulations included animations of the various scenarios and time history plots showing the development of the contact load and the subsequent motion of the Spar.

11.40 - 12.15 SAFETY OF MEMBRANE TYPE CARGO CONTAINMENT SYSTEM IN LNG CARRIER UNDER ICEBERG COLLISION

HOONKYU OH and WHASOO KIM, Hyundai Heavy Industries Co., Ltd.
JAEMYUNG LEE Pusan National University

The collision impact by an undetected iceberg should be considered to be an accidental load. Thereby, plastic deformations of the hull structure may be accepted provided the LNG will not leak out. Till now, view points of the safety evaluation have been limited to structural hull deformations by the collision. They have not examined effects of acceleration and vibration induced by the impact on the structure of LNG containment systems. In this paper, evaluations of the structural safety are focused on the response of LNG containment under impact-induced acceleration and vibration.

12.15 - 13.15 LUNCH

13.15 - 13.50 APPLICATION OF PLASTIC GRILLAGE ANALYSIS METHOD TO SHIP STRUCTURES UNDER ICE LOADS

Shewen Liu, Han-Chang Yu and Roger Basu, ABS

This paper is to apply an advanced plastic grillage analysis procedure to check the grillage strength of a DSME shutter tanker design. The limit loads/carrying capacity for three different designs are obtained using the grillage analysis method. The failure sequence of different structure components (main frames, stringers and web frames) for these 3 designs are also achieved. The results are verified with nonlinear FE analysis. It shows that the results from the grillage analysis methods match the nonlinear FE results very well. It proves

that the grillage analysis methods provides an easy alternative way to optimize the hull structure design under ice loads.

13.50 - 14.25 LOAD SHARING IN A GRILLAGE SUBJECT TO ICE LOADING

Jacob Abraham & Claude Daley, Memorial University of Newfoundland, Canada

In case of ice loading which is non-symmetric, the most heavily loaded frame will share some of the load with neighbouring frames. The paper examines the difference in load carrying capacity between frames in isolation and frames as part of a grillage, subjected to an unsymmetrical loading. Frames satisfying a range of ice classes and different stiffener forms were studied and compared. It is notable that larger, higher ice class structures are less well able to distribute the loads. This implies that higher class vessels will not only need to withstand higher loads, but will need to do so more locally than lower class vessels. Most practical experience has been gained with lower class vessels. Consequently this issue should be of concern for the many new large and high ice class vessels that are currently on the drawing boards.

14.25 - 15.00 STRENGTH ASSESSMENT FOR BOW STRUCTURE OF ARCTIC TANKER (107k) UNDER SHIP-ICE INTERACTION

Myo Jung Kwak, Joong Hyo Choi, Jae Hyung Park and Je Hyouk Woo Daewoo Shipbuilding & Marine Engineering Co., LTD

In this study, several nonlinear FE analyses were performed to identify the ultimate strength of stiffened panels under ice loads, the results of which were compared with those of the application of IACS Polar Class Rules in order to verify the adequacy of and safety margin in the Rule capacity for single stiffened panel. The study also includes the comparison of strength capacities for single stiffened panels with different types of stiffener and comparison of plastic behaviors of single stiffened panel and grillage structures. In addition, time domain numerical simulation based on explicit method was performed to calculate contact force under collision with level ice, which was compared with the ice load defined in the IACS Rule in order to propose proper mechanical properties of ice and numerical analysis procedure.

15.00 - 15.30 COFFEE

15.30 - 16.05 STRUCTURAL ANALYSIS AND ESTIMATION OF ICE LOAD ON THE BOW OF AN ICEBREAKING RESEARCH VESSEL

Chae Whan Rim, Korea Institute of Machinery & Materials

Ice load acting on an icebreaking vessel is estimated. Published measured ice loads are used to get the global load and the local load. The global load is for analyzing the bending behavior of the vessel during ice breaking operation mode and the local load for estimating the bow structural behavior. In the paper, the global load is predicted using the data from analysis of ship motion during ice breaking. And the local load is predicted using the data from strain gage attached to bow frames. Applying the estimation results, structural analysis of bow is carried out.

16.05 - 16.40 A STUDY ON HULL FORM DESIGN FOR ICE BREAKING ARCTIC LNG CARRIER

Jaeouk SUN, Jaebum KIM and Youngdal CHOI, STX Shipbuilding Co., Ltd., Changwon, KOREA
Reko-Antti Suojanen, Aker Arctic Technology Inc., Helsinki, FINLAND

In this study, we have evaluate the ship motion including the slamming impact for the extreme ice breaking bow based on the North sea condition by one of code which is developing with Seoul National University in KOREA. The major objectives of the study are to suggest sufficient Arctic LNGC based on the current energy development in arctic region which are results from cooperation investigation between STX shipbuilding and Aker Arctic Technology Inc.

16.40 - 17.15 CRUSHING BEHAVIOR OF STEEL PLATED STRUCTURES IN COLD TEMPERATURE: EXPERIMENTAL AND NUMERICAL STUDIES

Jeom Kee Paik, Pusan National University

The aim of this paper is to investigate the effect of cold temperature on crushing behavior of steel plated structures experimentally and numerically. Mechanical properties of steel in cold temperature are also examined. The insights developed from the present study shall be useful for accidental limit state design of vessels operating in arctic areas.

17.15 - 17.30 GENERAL DISCUSSION

