ICE FORCES AGAINST ARCTIC OFFSHORE STRUCTURES

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I. Background

This fourth quarterly report covers progress on the subject contract from September 1, 1982 to December 1, 1982.

The objective of this research program is to detemrine the lateral forces on artificial islands and offshore structures which are subject to moving sea ice.

This is the major factor governing the design of offshore facilities for petroleum production in the Beaufort, Chukchi, and Bering Seas, a frontier province which encompasses some 262 million acres with a risked mean oil equivalent of 30.8 billion barrels.

The approach which has been planned is to measure the internal ice stress at relatively large distances from such islands, to measure the ice displacement simultaneously, and to determine the effective island width all during ridgebuilding events. These events, which fracture the ice adjacent to the islands and structures, represent those time intervals when maximum total forces may be exerted on such man-made structures. They represent intervals of extreme lateral force which can be used to develop the design conditions for the island or structure. Although very local ice rideup events may disturb the gravel beaches or rock slopes of artificial islands, this can be repaired. The more significant issue has been whether the lateral resistance to movement of the entire artificial island or offshore structure is sufficient to withstand the maximum total force exerted by the moving fracturing ice. Allowance must be made in the design for the thickest ice and the highest velocity of ice movement expected during the operating life of a production facility. A detailed discussion of then-current practice in such designs was given in the first quarterly report.

In the second quarterly report, the completion and calibration of the electronic data telemetry system was described. The theory necessary for converting gauge output information into principal stress magnitude and direction was also developed during the second quarter, and detailed in that report. The calibration program for gauges frozen into ice blocks was begun, and the experimental determination of the stress concentration factor $\alpha(\Theta)$ for uniaxial stiff gauges was begun.

In the third quarterly report, the modification of the electronic telemetry system to accommodate an additional strain sensor was mentioned, and the improved reconfiguration of that system was described. A major technical contribution in the third quarterly report was the paper, "A Surface Integral Method for Calculating Ice Loads on Offshore Structures from In Situ Measurements", by Dr. J. B. Johnson.

II. Experimental Program

During the fourth quarter, intensive electronic system improvements and system checkout took place. The amount of electrical power consumed at the on-ice transmitting sites was larger than anticipated, once the final system configuration was tested, so it was decided to generate electrical power at each ice instrumentation site using wind generation. Three simple and reliable wind generators (winchargers) were purchased and the circuitry necessary to charge the on-site storage batteries in sequence was developed. A switching network for such charging was devised to permit uninterrupted data flow even during charging.

A mechanical design for a seafloor-referenced ice movement system involving two cables extending to the seafloor with a counterweight for constant tension on each cable was designed and constructed during the fourth quarter. A support frame and enclosure were also built.

The cables of the ice movement system were wrapped around a wheel attached to a shaft of a digital shaft encoder, set with a mechanical ratio so that a movement of 0.149 inches of cable would cause a single digit change. The digital electronic system was connected to the telemetry system as a direct digitally-modulated signal for transmission to the central data collection point. An unexpectedly extensive amount of electronic development time proved to be necessary to complete this part of the ice movement measurement system.

Continuation of the ice stress sensor calibration was deferred during the fourth quarter because of the priority given to preparation for winter field deployment.

Negotiations for the possible use of the Dome Petroleum Ltd. site

Uviluk, in the Canadian Beaufort Sea, continued during the fourth quarter.

A proposal for continuation of the program from December 1, 1982 to December 1, 1983, was also prepared and submitted during the fourth quarter, in order to permit field deployment and subsequent data reduction.

III. Plans for Next Quarter

Deployment of the ice stress sensor system is planned to take place in the next quarter, within ten days approval of the proposal for continuation. A minimum thickness of annual ice of 75 cm is required to install the uniaxial stress gauges and the ring-style strain gauges, and to interpret their outputs. Final approval from higher management of Dome Petroleum Ltd. for deployment at their Uviluk site is being sought. Mid-December 1982 would be an ideal deployment time.