PORT AND OCEAN ENGINEERING UNDER ARCTIC CONDITIONS
TECHNICAL UNIVERSITY OF NORWAY

OIL SPILLS IN THE ARCTIC

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INTRODUCTION

While there may be no direct obvious relationship between the theme of this Conference and oil spills on land, the fact of the matter is that the greatest single factor which has given a fresh impetus to northern development - at least in the part of the world where I come from - was the already substantial discovery of rich oil deposits in Alaska and the continuing search for similar deposits in the Canadian Arctic.

Thus, much of the port and ocean engineering in the Canadian Arctic is in one way or another related to the possible future transportation of large masses of oil overland.

Grave and legitimate, if not always well-informed, public concern for the impact a possible major oil spill could have on the arctic ecology caused the Canadian Government to sponsor a number of projects destined to provide input leading to the eventual formulation of a set of regulations governing the construction and operation of pipelines under arctic conditions.

I have the privilege to head a group of University of Ottawa scientists engaged in one of these projects. Our study commenced in the summer of 1970 and will continue for some time beyond the date of this Conference.

THE LOCATION OF EXPERIMENTAL SITES

One of the areas of immediate concern from our point of view is the Mackenzie River Delta and the vicinity of the arctic harbour of Tuktoyaktuk. To give you some idea of the land I am talking about I would like to show a first group of slides.

The major center in the general area you just saw is the town of Inuvik with a population of about 3,300. Inuvik is located adjacent to the eastern edge of the Mackenzie Delta approximately 75 miles south of the Beaufort Sea, some 1,200 miles northwest of Edmonton. It has an airport with a large concrete runway capable of accomodating huge transport planes such as the

Hercules as well as the normal passenger traffic. During the summer months Inuvik is supplied by boats and barges descending the Mackenzie River from rail and road terminals further south and after the onset of the freeze, a winter road is in operation until the spring thaw. Much of the scientific activity in the Northwest centers around Inuvik and all this may best be illustrated by another brief series of slides.

A team consisting of myself and of two biologists, Dr. M. Dickman and Mr. H. Muhle, travelled to the Mackenzie Delta area in September, 1970. Inuvik and Tuktoyaktuk were chosen as the bases for operation within the boreal forest and in the treeless tundra, respectively. Typical sites were selected in the vicinity of each of these places and several circular plots of land of two-meter diameter were marked out. Crude oil, in quantity of one hundred liters per plot, was spilled on some of these circular patches, while others were left to act as controls. Plants were collected in each area and detailed inventories of these plants were subsequently compiled by Muhle.

The plots were placed in fairly homogeneous vegetation types. Care was taken to choose plots which may be considered representative of the respective areas. The spill site at Inuvik lies about three quarters of a mile to the west from the Mackenzie Valley Pipeline Research Project. The site at Tuktoyaktuk is situated about one mile south of the airstrip. Both sites can be described as moderately well drained.

The object of the spills is to observe the extent of penetration and diffusion of the oil both vertically and horizontally after a considerable lapse of time, as well as its effect on vegetation.

EFFECTS OF THE SPILL AFTER NEARLY ONE YEAR

For the purpose of this presentation we will be better served by looking at some slides taken at the beginning of August, 1971 when I revisited the area ten and a half months after the oil spill. In these slides you will be able to see the conditions at the edge and in the immediate vicinity of the actual area on which oil was deposited. These slides show very clearly that no visible adverse effect on the surrounding vegetation resulted from the presence of a neighbouring large mass of oil. Indeed, certain plants actually grew in the midst of oil-drenched soil.

Cores were taken right down to the permafrost table within the area of the spill and at distances of 0.3, 0.6 and 1.5 meters from the edge of the spill. These cores have been examined for oil content by the Petroleum and Gas Laboratory of Canada Department of Energy, Mines and Resources. The results are reported in the Appendix. From these results it is clear that only a moderate quantity of oil seeped away from the original spill area and most of it is still contained therein.

An important fact could be observed in both the woodland and treeless area. The top of the permafrost was much deeper below the surface within the oil-drenched area than it was only a small distance away from it.

I find two possible explanations for this phenomenon. On the one hand, the spontaneous oxydization generates heat and, on the other hand, the dark colored oil-drenched area absorbs solar radiation more readily than does the surrounding soil. Be it as it may, the cores taken by forcing the corer right down to the permafrost were, on the average, about 30-cm long, while the other cores averaged about half this length.

It must be realized that the spills were of modest proportions, even if spill density was of some 30 liters per square meter which is quite considerable. This notwithstanding, I feel that the observed phenomenon would repeat itself in a large-scale, or even a catastrophic-scale, spill. The oil will, in all probability, melt the upper layer of the underlying permafrost and it will thus create a fairly stable basin in which it will remain contained. All this, of course, provided that the oil does not enter into streams, rivers, or lakes.

OTHER STUDIES PROPOSED BY THE UNIVERSITY OF OTTAWA GROUP

I should now add a few words about the microbic breakdown of crude oil. Large samples of arctic soil complete with the vegetation were brought to Ottawa at the end of summer, 1970.

Preliminary experiments on the possibility of breakdown of oil by microorganisms found in these samples were carried out by Drs. D. J. Kushner and M. Kates and Mr. D. Shindler, Departments of Biology and Biochemistry, University of Ottawa. No evidence of any rapid breakdown of oil was found in these experiments. However, since it is known that microorganisms can degrade oil, it was suggested that further experiments should be carried out to determine if microorganisms in arctic soil can do this at all, and if such degradation can be speeded up. The latter might be accomplished by such methods as adding nitrogen sources to soil, since a lack of nitrogen could well prevent growth of bacteria; better aeration, since the microbial breakdown of most components of crude oil would certainly be an aerobic process; finally, by the use of enrichment cultures and other microbiological techniques to find new microorganisms with the ability to break down oil rapidly at low temperatures.

In my brief summary which was published in the collection of the Abstracts sent to all the participants of this Conference, reference was made to my plans for a much larger spill in an enclosed basin area in which the migration of the oil could be followed along the small drainage channels and streams. This more ambitious project involves considerable problems of logistics and financing and could not, unfortunately, be undertaken this summer.

Mr. Chairman, Ladies and Gentlemen, thank you for your forbearance and let me take this opportunity to express my thanks to, and admiration for, the organizers of this Conference which I am sure you are all enjoying as much as I do.

APPENDIX

Oil content of core samples determined by Soxhlet Extraction, followed by quantitative recovery of the oil from the benzene solvent

Location of sample	Part of the core	Oil %, by weight on air-dried sample
Inuvik		
Within the spill	top	20.74
Within the spill	middle	51.85
Within the spill	bottom	52.32
0.3m from spill edge	top	5.21
0.3m from spill edge	middle	6.04
0.3m from spill edge	bottom	9.04
0.6m from spill edge	top	2.67
0.6m from spill edge	middle	3.12
0.6m from spill edge	bottom	3.87
1.5m from spill edge	top	1.78
1.5m from spill edge	middle	4.12
1.5m from spill edge	bottom	0.37
Tuktoyaktuk		
Within the spill	top	22.00
Within the spill	middle	3.64
Within the spill	bottom	1.07
0.3m from spill edge	top	3.42
0.3m from spill edge	bottom	3.65
0.6m from spill edge	top	3.67
0.6m from spill edge	middle	3.22
0.6m from spill edge	bottom	3.06
1.5m from spill edge	top	1.96
1.5m from spill edge	bottom	2.03