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Controlled Combustion Tests Carried Out Near Rimouski

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REPORT ON CONTROLLED COMBUSTION TESTS CARRIED OUT NEAR RIMOUSKI

By: Bernard Coupal, Head
Chemical Engineering Department,
University of Sherbrooke,
Sherbrooke, Quebec.

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ABSTRACT

Six combustion tests were performed on oil. Ceuta crude oil and Bunker C oil were burned both on water and on ice. The burning of these oils was effected by using peat moss as a wicking agent and diesel fuel as a promoter. Combustion efficiencies on the order of 85% were attained. It was concluded that this combustion technique is a feasible method of disposing of oil spills. Recommendations are made for future research.

RÉSUMÉ

Six expériences de combustion ont été faites sur l'huile. L'huile brute Ceuta et l'huile Bunker C ont brûlé sur l'eau et sur la glace. Le brûlement de ces huiles a été effectué à l'aide de touche comme agent comburant et de l'huile diesel comme promoteur. L'efficacité de la combustion a atteint l'ordre de 85%. Il a été conclu que cette technique de combustion comme méthode de disposition de déversements d'huile est réalisable.

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The work in this study was performed under contract to the Environmental Emergency Branch, Environmental Protection Service, Environment Canada.

The terms of reference were as follows: To conduct for the Department of the Environment a study on a field trial method of disposing of oil through burning, using peat moss as a wicking agent.

1 INTRODUCTION

This study is the continuation of a previous study, "The Use of Peat Moss in Controlled Combustion Technique", (EPS 4-EE-72 1, September 1972). In the previous study combustion tests were conducted in a steel vat. The effects of aging of the oil, and the amounts of wicking agent (peat) and promoter (kerosine, gasoline or diesel fuel) were investigated. The conclusion was drawn that burning did show potential as a feasible and practical method of disposing of oil.

The purpose of the present study was to test the burning method on larger quantities of oil in an open environment. Ceuta crude and bunker C oils were combusted in six tests at a site near Rimouski, Quebec. The tests include spills on ice and spills on water above ice.

2 EXPERIMENTAL

2.1 Choice of Location

A site in a small bay on the St. Lawrence River, as shown in Figure 1, was chosen for the following reasons:

a) The site is on the St. Lawrence River where oil transport traffic is fairly heavy. Thus with a high risk of actual spills, the site is fairly representative of those where burning techniques might be utilized.

b) The site is affected by tides; consequently, at low tides tests can be conducted on ice, and at high tides, tests can be conducted on water above ice, the ice being five to six inches under the surface of the water under these conditions.

c) The site is close to the City of Rimouski and the Rimouski Campus of the Université du Québec allowing the easy transportation of materials to and from the site.

2.2 Procedure

One day before each test, the snow was removed from the ice surface, over a 15 by 18 foot area. The following day oil was spread and peat mixed with diesel fuel, was spread on the oil. Ignition was then effected with a torch soaked in gasoline.

The amount of peat (wicking agent) and diesel fuel (promoter) used were the optimal quantities as determined in the previous study. It was determined that a ratio of 4 pounds of peat per 9 gallons of oil, and 1/2 litre of promoter per pound of peat was an optimal combination. The peat was soaked in the diesel fuel prior to application.

The types of oil used were Ceuta crude and Bunker C. The viscosity of the Ceuta crude was 28 cp at 70 °F (21 °C) and 3500 cp at 70 °F (21 °C). Figure 2 gives the rheogram for Ceuta crude. The rheogram is a plot of shear stress versus rate of shear as determined on a Fan viscometer. The slope of

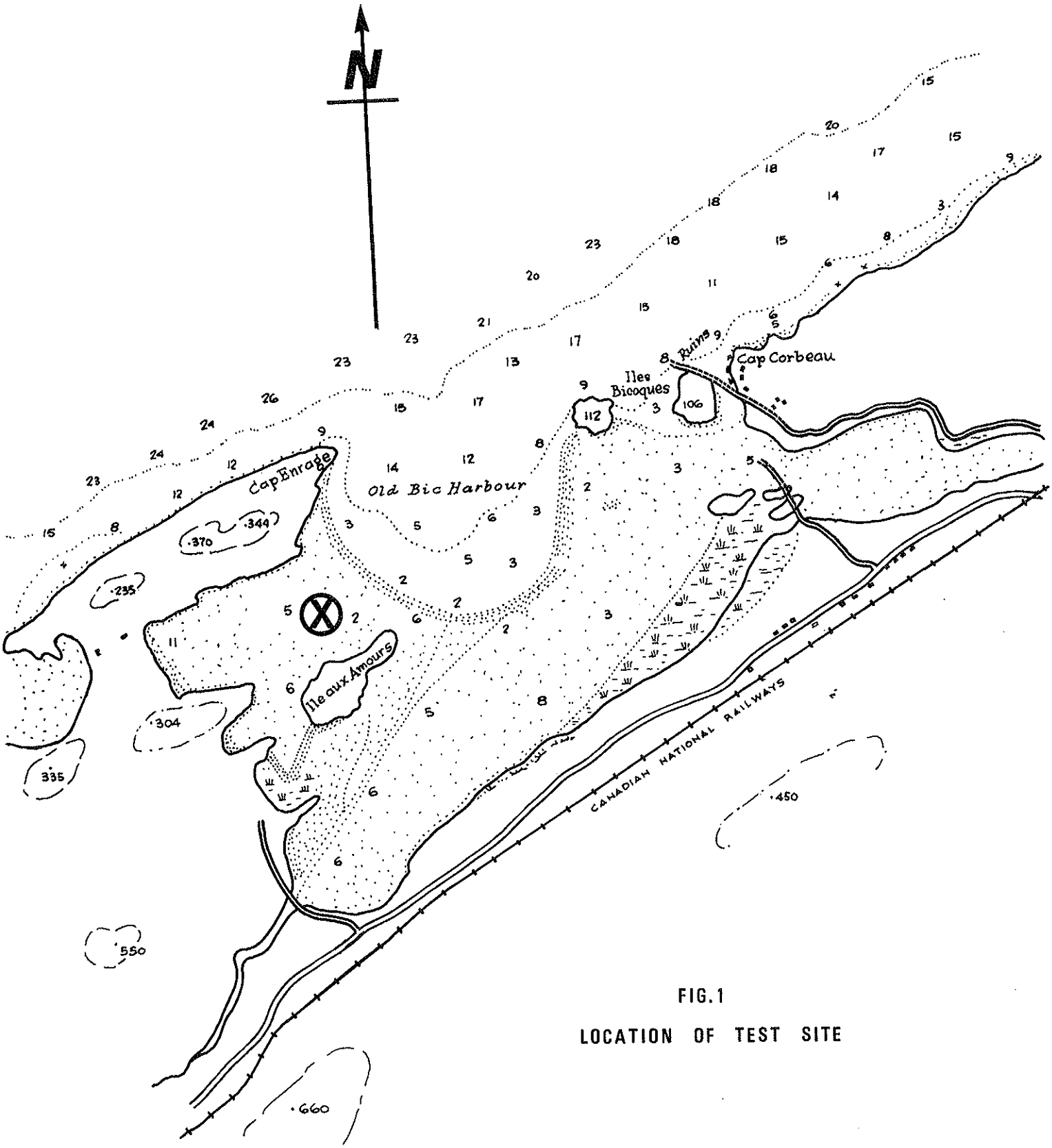


FIG. 1

LOCATION OF TEST SITE

the line gives the viscosity in centipoises (cp). The Bunker C used in this test has a viscosity on the same order of magnitude as that used in the previous tests.

2.3 Observations

2.3.1 Physical properties. Overall physical properties were observed, including; the amount of spreading, length of time that combustion was sustained, behavior of oil and residue on ice and the relative intensity of combustion. These results are noted in Appendix A.

3 RESULTS

3.1 Efficiency of Combustion

The efficiency of combustion has been evaluated by calculating the ratio of the oil consumed by combustion, and the amount originally present. These results are presented in tables 2 and 3. The efficiencies averaged 85% over all 6 tests. It was also observed that there is no large variance between the two types of oil that were combusted in this experiment. Cueta crude appears to burn only somewhat more efficiently.

3.2 Smoke Determination

The smoke generated by the combustion was very dense directly over the test site, see Figure 3 and 4. However, one-half mile downwind the density was 40% as measured by the Ringelman chart. The smoke dispersed readily even though the wind velocity was low during the experiments.

Air samples taken at 100, 200 and 500 feet from the site did not contain any carbon particles. The surrounding area was surveyed after completion of the tests for sedimentation of carbon particles; no deposits were found. Bonsanquet et al (Pasquill, *Atmospheric Diffusion,* Von Nostrand) developed the following empirical formula to evaluate the amount of deposition of a solid from a point source.

$$D = 0.0032\ Qb \left(20\ (H/x)\right)^{m+2} \frac{\exp\ (-20\ (H/x))}{H^2\ \Gamma\ (m)}$$

where

- D : amount of solids fallen at a distance x from the source
- Q : amount of solids in the source
- b : fraction of time, the wind is in a 45-degree sector from the source enclosing the ground position involved.
- m : $20\ v_s/u$
- v_s : terminal velocity of the particle of solid
- u : mean wind velocity
- $\Gamma(m)$: gamma function
- H : effective height of the source

RHEOGRAM OF CRUDE OIL

(CUETA CRUDE)

TEMPERATURE 21° C

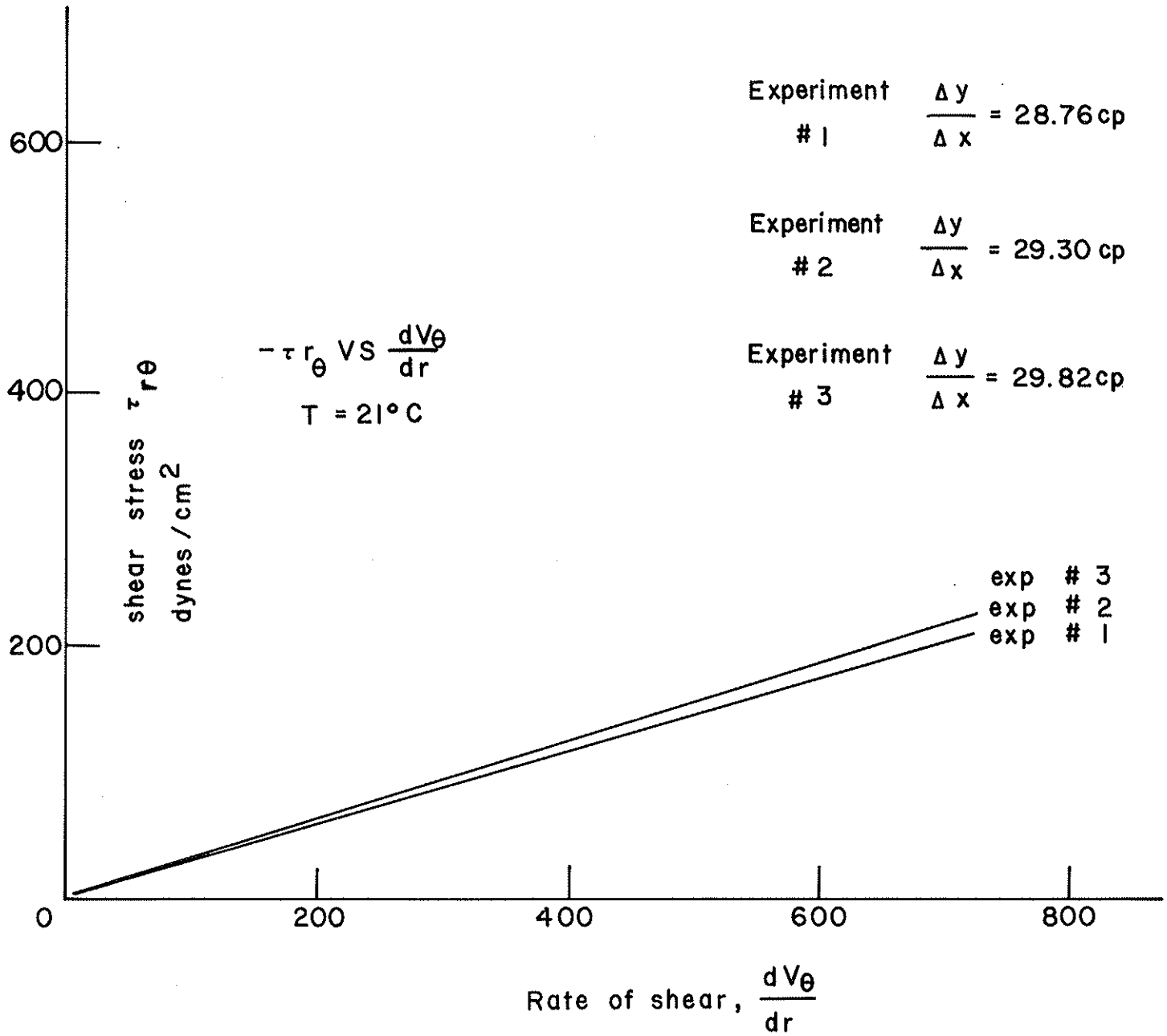


FIG.2

TABLE 1

EFFICIENCY OF COMBUSTION FOR CEUTA CRUDE OIL

Test Number	1	2	3
Volume of oil, U.S. gal.	45	75	110
Specific gravity of oil	0.86	0.86	0.86
Weight of oil, lbs	324	539	791
Weight of residue, lbs	44	95	125
% of oil in residue, %	76	78	78
Efficiency: oil burnt / % oil present	89	86	87

In the case of this experiment, the effective height of the source was large because of the relative importance of the buoyancy of the particles compared to the wind velocity. It can be concluded, therefore, by application of the above formula that sedimentation of the carbon particles took place a great distance from the test site.

3.3 General Observations

3.3.1 ***Time duration of combustion.*** Combustion time varied from 10 minutes to 40 minutes. There is no apparent relationship between the length of time for combustion and any of the other parameters. Further work would be needed to establish a time dependence.

3.3.2 ***Spreading.*** As could be anticipated, a direct relationship between the intensity of combustion and spreading was observed. The more spreading that occurred; the less efficient was the combustion due to the thinning of the slick, and actual physical losses of oil in crevaces and holes.

3.3.3 ***Peat Adsorption.*** It was observed that Ceuta crude oil adsorbed to the peat more readily than did Bunker C. From this it follows that peat functions as a better wicking agent in Ceuta crude. This could account for some of the difference in the efficiency of combustion between the two oils.

3.3.4 ***Residue.*** The residue consisted of lumps of intimately mixed peat and oil (heavier fractions). No traces of promotor (diesel fuel) were found.

TABLE 2

EFFICIENCY OF COMBUSTION FOR BUNKER C OIL

Test Number	4	5	6
Volume of oil, U.S. gal.	45	75	110
Specific gravity of oil	0.95	0.95	0.95
Weight of oil, lbs	358	596	873
Weight of residue	93.5	126	124
% of oil in residue, %	80	81	74
Efficiency: oil burnt / % oil present	79	82	89

4 CONCLUSIONS

The combustion of fresh oil on ice and water can be performed with efficiencies on the order of 85% using the techniques described in this report, and under conditions as outlined in this report. The technique appears to have potential in actual spills where the oil is contained naturally or by booms. The peat and promoter mixture could be spread on the oil with the use of pneumatic equipment.

The author is well aware that the combustion of oil produces a smoke column which itself is a form of pollution. It is felt, however, that the total damage to the environment is only a small fraction of that which is done by oil in water.

5 RECOMMENDATIONS FOR FURTHER WORK

Burning tests on the ocean would be necessary to assess the full potential of this technique. These experiments should include testing under conditions with both waves and currents present. The possibility of burning oil contained in a boom could also be investigated. The author will be proposing further tests on a site near Rimouski which would simulate sea-type conditions.

APPENDIX A

PARAMETERS OF THE COMBUSTION TESTS

PARAMETERS OF TEST NUMBER 1

Test #1, March 7, 1973

Oil	:	Crude, CEUTA
Volume	:	45 gal. (U.S.)
Peat used	:	16 lbs at 37% moisture content
Promoter	:	8 liters of Diesel oil
Area of test	:	250 ft^2
Average thickness of oil	:	0.3 inches
Temperature of air	:	4 °C
Wind velocity	:	5 mph North-West
Viscosity of oil	:	28 cp at 70 °F
Specific gravity of oil	:	0.86
Weight of residues	:	44 lbs
Condition of surface	:	ice present, no water

Comments

The promoter and the peat had been measured and mixed together a few hours before. The mixture was spread and, because of the low viscosity of crude, sank into the oil. Ignition was very easily accomplished and the fire propagated instantaneously. The combustion lasted from 2:20 to 2:55 p.m. At the beginning, the combustion generated very heavy black smoke made up of carbon particles. After the combustion, the residues were collected. This collection was very easy to make, because the lumps did not stick to the ice surface. Diffusion of oil through the ice (2 1/2 thick) did not take place. The dispersion of heavy smoke took place rather rapidly, even with the prevailing wind conditions.

Test #2, March 7, 1973

Oil	:	Crude, CEUTA
Volume	:	75 gallons (U.S.)
Peat used	:	28 lbs at 37% moisture content
Promoter	:	14 liters of Diesel oil
Area of test	:	250 ft^2
Average thickness of oil	:	0.5 inches
Temperature of air	:	4 °C
Wind velocity	:	5 mph North-West
Viscosity of oil	:	28 cp at 70 °F
Specific gravity of oil	:	0.86
Weight of residues	:	95 lbs
Condition of surface	:	5'' of water on top of the ice bed

Comments

The experiment took place in similar conditions to that of Test #1. The combustion was rapid and so active that the test area slowly moved because of the melting of snow and ice. The final surface had increased its area by 15%. The combustion started at 3:00 p.m. and ended at 3:40 p.m. The dispersion of generated smoke was rapid even with the low wind conditions.

Test #3, March 7, 1973

Oil used	:	Crude, CEUTA
Volume	:	110 gallons (U.S.)
Peat used	:	36 lbs at 37% moisture content
Promoter	:	18 liters of Diesel oil
Area of test	:	250 ft^2
Average thickness of oil	:	0.7 inches
Temperature of air	:	4 °C
Wind velocity	:	5 mph North-West
Viscosity of oil	:	28 cp at 70 °F
Specific gravity of oil	:	0.86
Weight of residues	:	125 lbs
Condition of surface	:	5'' of water on top of the ice bed

Comments

The combustion lasted ten minutes and was very intense. The testing area almost doubled in size because of snow and ice melting. It seems that the duration of the combustion is not affected by the quantity of oil.

Test #4, March 9, 1973

Oil used	:	Bunker C
Volume	:	45 gallons
Peat used	:	16 lbs at 37% moisture content
Promoter	:	8 liters of Diesel oil
Area of test	:	250 ft^2
Average thickness of oil	:	0.3 inches
Temperature of air	:	0 °C
Wind velocity	:	8 mph North-West
Viscosity of oil	:	3500 cp at 70 °F
Specific gravity of oil	:	0.95
Weight of residues	:	93.5 lbs
Conditions of surface	:	ice (experiment performed at low tide)

Comments

The ignition took place easily and the fire propagated rapidly. The combustion lasted ten minutes and released more heat than test #1, because the snow melted around the test site.

Test #5, March 9, 1973

Oil used	:	Bunker C
Volume	:	75 gallons
Peat used	:	28 lbs at 37% moisture content
Promoter	:	14 liters of Diesel oil
Area of test	:	250 ft^2
Average thickness of oil	:	0.5 inches
Temperature of air	:	0 °C
Wind velocity	:	8 mph North-West
Viscosity of oil	:	3500 cp at 70 °F
Specific gravity of oil	:	0.95
Weight of residues	:	126 lbs
Condition of surface	:	ice (experiment performed at low tide)

Comments

The combustion was rapid. The heat of combustion expanded the area of the test site. Smoke dispersed rapidly. Part of the oil went under the ice and did not burn.

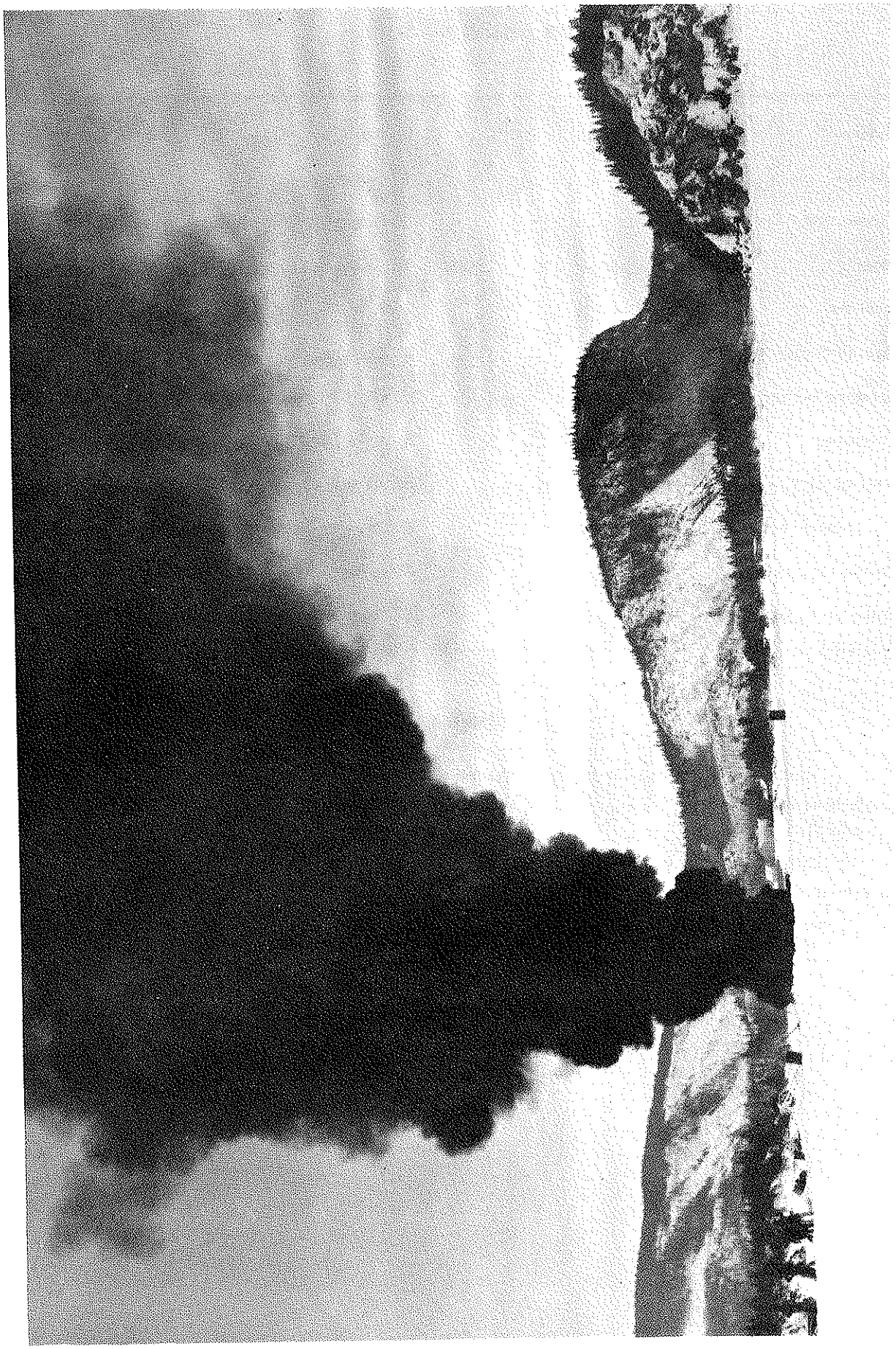
Test #6, March 9, 1973

Oil used	:	Bunker C
Volume	:	110 gallons
Peat used	:	36 lbs at 37% moisture content
Promoter	:	18 liters of Diesel oil
Area of test	:	250 ft^2
Average thickness of oil	:	0.7 inches
Temperature of air	:	0 °C
Wind velocity	:	8 mph North-West
Viscosity of oil	:	3500 cp at 70 °F
Specific gravity of oil	:	0.95
Weight of residues	:	124 lbs
Condition of surface	:	6'' of water on top of ice

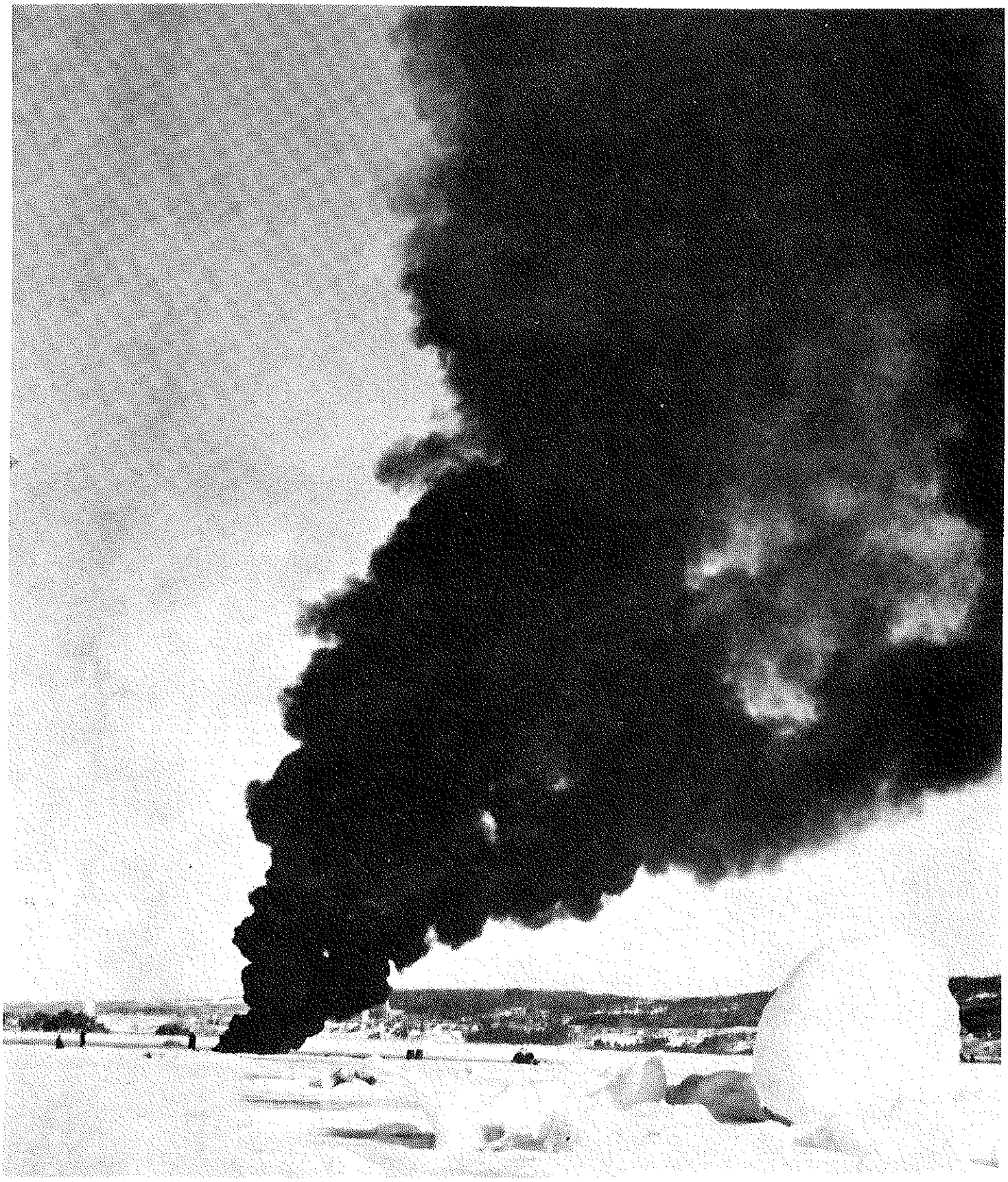
Comments

Combustion released so much heat that the test site doubled its area. Combustion did not last longer than the previous tests.

Some of the tests were photographed under different angles and two of these photographs are included in the Appendix.



TEST ON CRUDE OIL



TEST ON CRUDE OIL