CONTAINED CONTROLLED BURNING OF SPILLED OIL DURING THE EXXON VALDEZ OIL SPILL

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ABSTRACT

During the evening of the second day following the Exxon Valdez oil spill, an estimated 15,000 to 30,000 gallons (57,000 to 114,000 liters) of North Slope crude oil were eliminated using in-situ combustion techniques. The oil was collected with 3M's FIRE BOOM towed in a U-configuration behind two fishing boats. Working with 500-foot- (152-meter-) long tow lines, a 450-foot - (137-meter-) long boom was moved at about 1/2 to 1 knot (0.26 to 5.2 meters/second) through slightly emulsified oil patches in the downwind region of the spill. Once oil had filled the downstream portion of the "U", and the boats were clear of any surrounding slicks, a gelled-fuel igniter was released from one of the tow boats. Shortly after ignition, flames gradually spread out over the entire area of the contained oil. As flames reached 200 to 300 feet (61 to 91 meters) into the air, the area of the contained oil layer (and therefore the size and intensity of the fire) could be controlled by adjusting the speed of the vessels. The total burn time was approximately 1 hour and 15 minutes; however, the intense part of the burn lasted for about 45 minutes. Using several methods to estimate the volume of oil collected, this volume (likely between 15,000 and 30,000 gallons) resulted in approximately 300 gallons (1,136 liters) of stiff, taffy-like burn residue that could be picked up easily upon completion of the burn. The controlled elimination of crude oil therefore resulted in an estimated 98% or better efficiency of burn.

OIL COLLECTION

During the afternoon of Saturday, March 25, 1990, 500 feet (152 meters) of 3M FIRE BOOM were loaded aboard two fishing vessels, the Midnight Sun and the Sea Ruby. Both vessels left the dock at the Alyeska Valdez Marine Terminal at approximately 1423 and headed south out of the Port Of Valdez Alaska. Shortly after the vessel left the terminal, word was received over the radio that permission had been granted to conduct a burn test in the area

Environment Canada. Arctic and Marine Oil Spill Program Technical Seminar, 13th. June 6-8, 1990, Edmonton, Alberta, Canada, Environment Canada, Ottawa, Ontario, 305-313 pp, 1990.

generally off the mouth of Fidalgo Bay. At approximately 1800, a spotter helicopter from Alyeska Pipeline Service Company flew over and directed the operations to a location approximately 5 to 7 miles (8 to 11 kilometers) west of Goose Island (Figure 1). It was felt that thick oil patches could be intercepted there and that clear open waters could also be found nearby so that the contained oil could be burned at a safe distance from any surrounding oil layers.

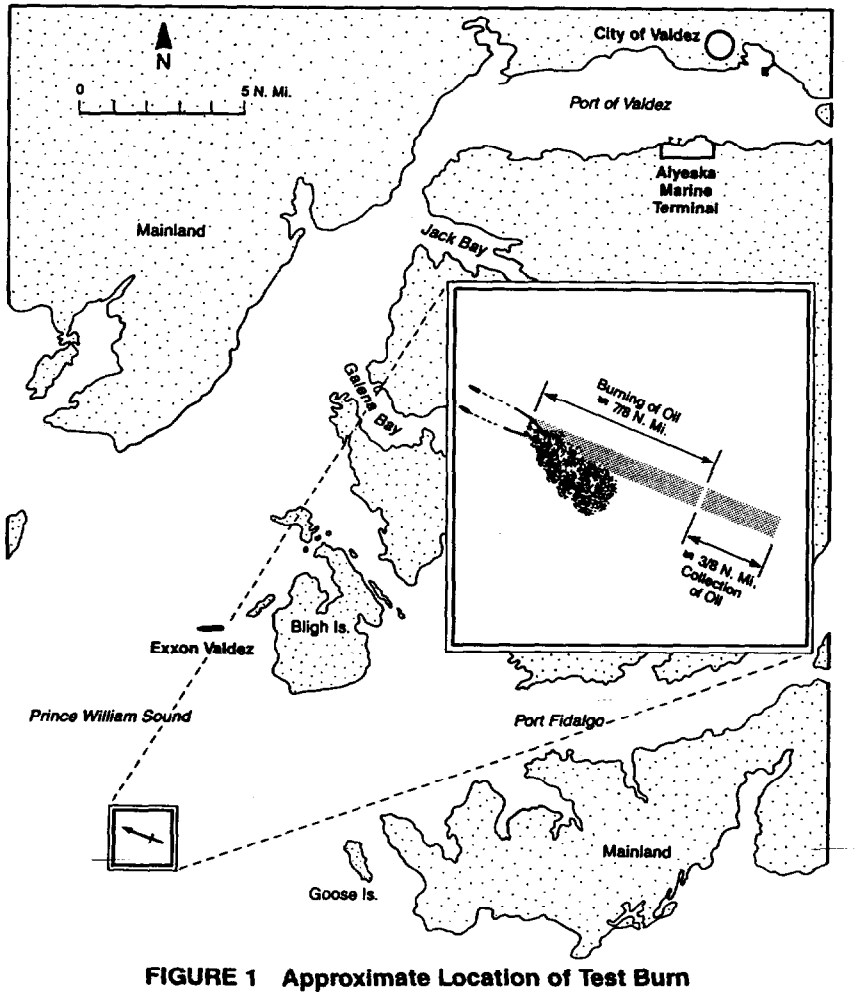

FIGURE 1 Approximate Location of Test Burn

At about 1845 the FIRE BOOM was deployed and taken under tow behind one of the fishing boats. The boom was accidentally jerked into motion, causing damage to one of the leading boom sections. Within minutes, one 50-foot (15.3-meter) section of boom had been removed, leaving 450 feet (137 meters) of boom for containment of oil in the designated collection area. After the boom was placed in a U-configuration, it was towed at about 3/4 knot with an opening between the two tow boats of approximately 100 to 130 feet (30 to 40 meters). Figure 2 illustrates the 3M FIRE BOOM configuration and the nature of the oil during the oil collection phase of the test burn.

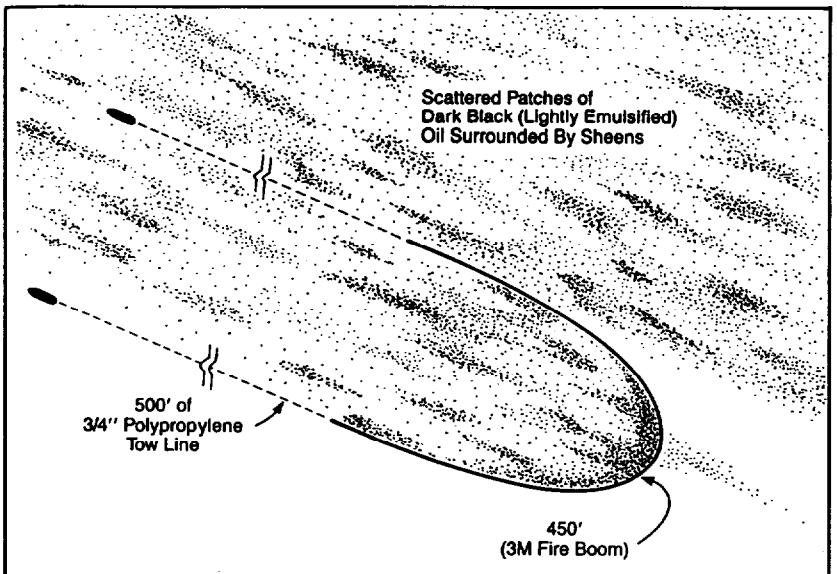

FIGURE 2 Fire Boom Configuration During Collection

After the boom was towed through scattered oil slicks for about 1/2 hour (about 2010), a decision was made to attempt a burn of the collected oil. It was dark upon completion of the oil collection phase; however, it could be seen with the vessel's spot lights that the waters forward of the towing boats were relatively free of any oil.

During the oil collection phase, sorbents were dipped periodically into the oil passing between the tow boats to assist with a very rough approximation of the average thickness of the oil It was felt that the average oil thickness was probably on the order of a hundredth to several hundredths of an inch (0.3 to 1 mm). In places, the patches of oil nearly filled the space between the tow boats and appeared to be close to a tenth of an inch (2 to 3 mm) in thickness (or more). Before any ignition of the oil was attempted, it was estimated that the oil encounter rate could easily approach several hundred gallons/minute (i.e., well over 1,000 liters/minute). Since oil had been collected for about 1/2 hour, it was believed that the volume of oil contained within the boom could be on the order of 10,000 gallons (approximately 38,000 liters) or more.

OIL IGNITION

Plans had been made to ignite any captured oil using a Helitorch (inset of Figure 3). However, because of darkness, it was felt that ignition should be attempted using a hand-held igniter. A small plastic bag of gelled gasoline (approximately 1/2 liter of fuel and a handful of Sure Fire gelling mix) was prepared and ignited, and then allowed to float back into the oil within the boom. The ignition of the contained crude oil required several minutes because of the single point-source igniter. Had the Helitorch been used, numerous ignition points could have been spread throughout the contained oil, thus providing a much more efficient heating and ultimate ignition of the oil.

Samples of the oil prior to ignition were not retained; however, the crude oil did have the color and consistency of a lightly emulsified oil layer (perhaps 20% to 30% water-in-oil). The floating patches of oil collected with the FIRE BOOM had been on relatively calm seas for an estimated 30 to 40 hours.

The gradual spread of flame over the entire surface area of the contained oil was very slow at first. Within approximately 10 to 15 minutes, however, the fire was big enough to accelerate the breakdown of emulsions and the release of volatile vapors over most of the contained oil. By the time the fire reached the entire region of contained oil, flames were already reaching more than 150 to 200 feet (45 to 60 meters) into the air. At the stern of each towing vessel (approximately 650 feet, or 200 meters, from the fire), the heat from the fire was noticeable, but not uncomfortable.

BURN PHASE

The entire burn period (including ignition) lasted about 1 hour and 15 minutes. The intense portion of the burn lasted about 45 minutes. The entire burn was conducted shortly after dark -- the photo in Figure 3, however, helps to provide a similar day-time view of what the burning oil and FIRE BOOM looked like. The test burn in Figure 3 was conducted off Spitsbergen in July 1988 in cooperation with 3M and various government, academic and industry groups from Norway. The Spitsbergen burn involved 300 feet (91 meters) of 3M FIRE BOOM and approximately 500 gallons (1,893 liters) of Statfjord crude oil.

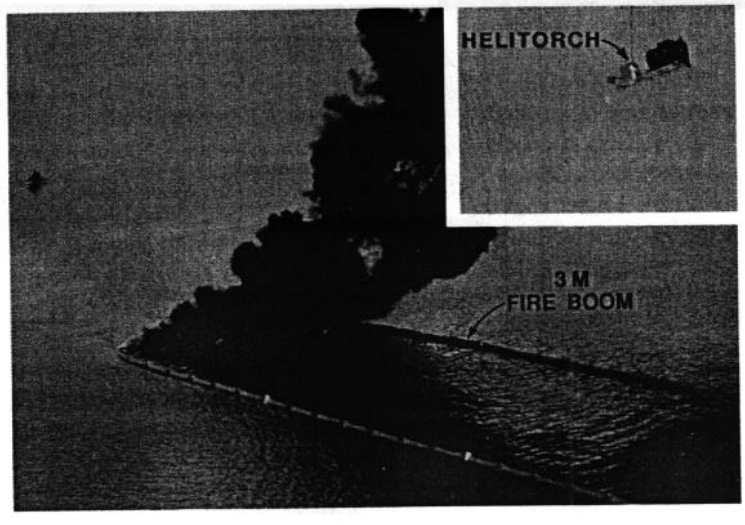

FIGURE 3 In-Situ Burning Of Crude Oil --Spitsbergen, July, 1988

During the test burn involving crude oil from the Exxon Valdez, it was noted that the area of burning oil could be controlled quite easily by adjusting the speed of the towing vessels. If the vessels slowed down to a near standstill, the burning oil would move forward toward the leading ends of the FIRE BOOM. If the vessels speeded up, the leading edge of the burning oil could be moved back toward the apex of the U-configuration. Throughout most of the test burn, a slow towing speed of about 1/2 knot (0.26 meters/sec) was maintained while keeping the burning oil back in the downstream 1/3 to 1/2 of

the boom's containment area. Based on the approximate oil holding capacity of a 450-foot boom held in a U-configuration (Figure 4), the oiled region about 1/3 of the way toward the leading ends of the boom could hold about 100 barrels (15,900 liters) per inch of oil depth. A total containment volume of 20,000 to 30,000 gallons (76,000 to 114,000 liters) could therefore be accounted for with an average oil depth of 5 to 7 inches (13 to 18 centimeters). This potential holding capacity can be compared with the observed oil encounter rate (previous section) and the oil burn rate (next section) to provide a reasonable estimate of the volume of oil eliminated during the test burn.

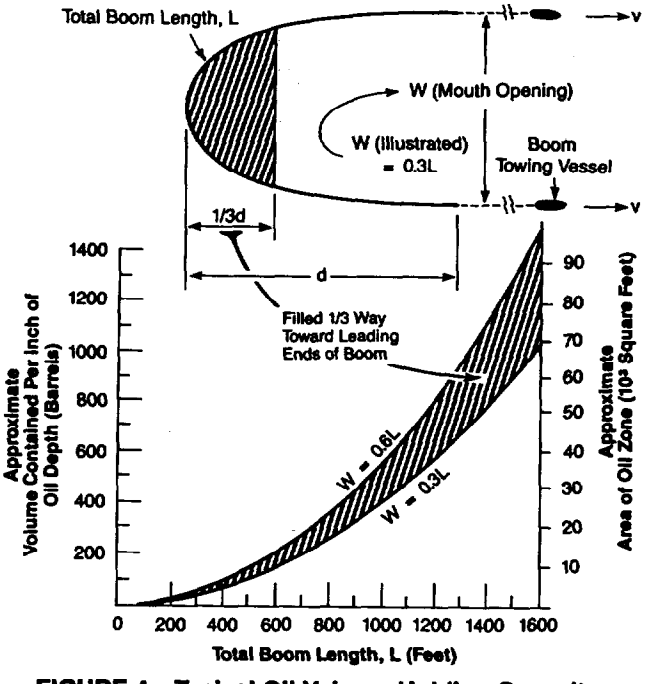

FIGURE 4 Typical Oil Volume Holding Capacity

The seas during the test burn remained calm, with only a light breeze out of the west, northwest. The direction of tow during collection and burning of the oil was maintained into the wind (Figure 1). After approximately 45 minutes of very intense burning with flames sometimes reaching 200 to 300 feet (61 to 91 meters) into the air, the fire began to subside. This reduction took another 10 to 15 minutes, resulting in an obviously smaller and less dramatic burn. At about 2130, 1 hour and 15 minutes following ignition, the fire went out . The boom was then allowed to go slack; one of the towing vessels held on to both tow lines; and the second boat moved back to inspect the boom and burn residue.

BURN RESULTS

Inspection of the 3M FIRE BOOM revealed an expected amount of thermal stress to certain components of the boom resulting in a slight loss of freeboard and some embrittlement of the fabric between flotation segments. These effects of the burn were not surprising since the boom used was the last of an earlier boom design. Modifications to the design and materials used in the boom have significantly enhanced the retention of freeboard and the durability of the boom's thermal protection components. The sacrificial PVC covering on the outside of the boom had melted off to the waterline as it is designed to do. The forward-most leading ends of the boom were still unaffected by the fire, as were the polypropylene towing lines. The boom was in satisfactory condition to be used for additional oil collection and burning operations.

Upon inspection of the remaining oil residue, it was discovered that there was no free-floating (unburned) crude oil inside or immediately outside the FIRE BOOM. The remaining oil residue was of a taffy-like consistency, covering an estimated area of approximately 100 square feet (9.3 square meters). The residue had been swept back by the boom's forward motion to an average thickness of about 4 to 5 inches (10 to 13 centimeters), representing a total volume of about 300 gallons (1,136 liters). There was no apparent burn residue floating downstream of the boom; however, some residue had managed to build up and cling to the boom on its outside, downstream side. One of the towing vessels remained with the boom and residue, while the other returned to the Port of Valdez The burn residue was to be picked up at first light, and a sample of the residue returned to the Exxon Command Center.

Upon completion of the burn test, boom deployment charts (Figures 4 & 5) were examined and used to estimate that the burn area during the previous night's test could have varied between 5,000 and 10,000 square feet (465 and 929 square meters). Combined with the fact that most relatively fresh, thick crude oil layers burn at about 0.07 gallons/square foot/minute (i.e., about 0.1 inch/minute or 2 to 3 mm/minute regression rates), the volume elimination rate could be estimated at about 350 to 700 gallons/minute (1,325 to 2,650 liters/minute). Uncertainties exist involving the actual burn rates of emulsions and the actual burn areas experienced throughout the test burn. However, the elimination rates of from 350 to 700 gallons/minute should reflect reasonable approximations for the total amount possibly burned. A conservative estimate of the total volume of oil burned, based on 45 minutes of intense burn only, would range from 15,750 to 31,500 gallons (approximately 60 to 120 cubic meters).

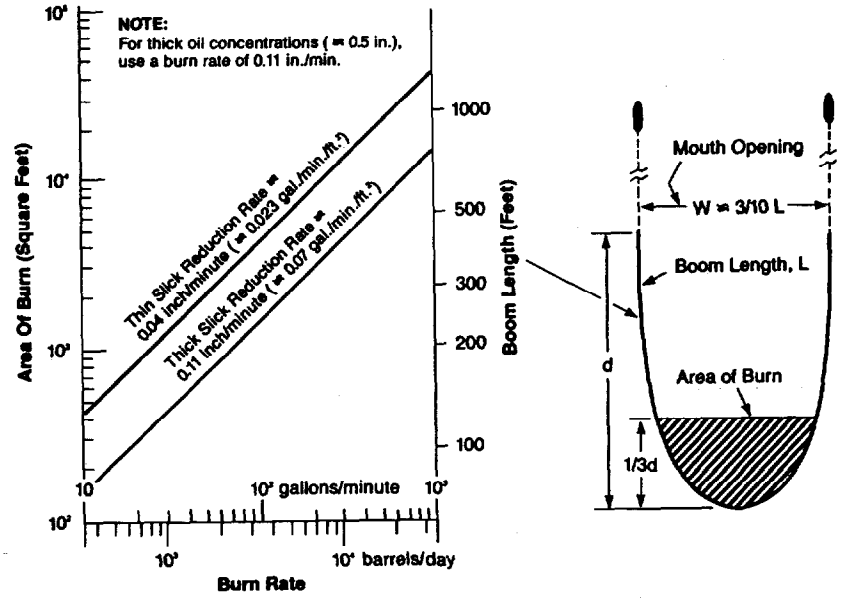

FIGURE 5 Approximate Burn Rate Versus Boom Length

SUMMARY

The above oil volume estimates can be summarized as follows:

Oil Encounter Rate -- on the order of 10,000 gallons (38,000 liters) or more
Boom Holding Capacity -- 20,000 to 30,000 gallons (76,000 to 114,000 liters)
Burn Rate -- 15,750 to 31,500 gallons (60,000 to 120,000 liters).

It is evident from these estimates that the total amount burned on the evening of the second day following the Exxon Valdez spill could conceivably be between 15,000 and 30,000 gallons (57 to 114 cubic meters). Using the lower estimate of 15,000 gallons, the 300 gallons of burn residue would suggest that approximately 2% of the original oil was left upon completion of the burn. If the 30,000-gallon figure was used, the burn residue would represent only 1% of the original oil. The achievement of a 98% to 99% efficiency of burn is consistent with numerous other controlled burns involving floating crude oil contained within a barrier. This burn, however, is very likely the first time that oil has been eliminated through combustion involving an actual accidental oil spill contained within a fire containment boom.

AUTHOR'S NOTE

It should be recognized that the elimination of spilled oil using in-situ burning must be considered in light of the full range of potential impacts (safety, air quality, etc.) associated with the burning of oil on water. The mechanical removal of spilled oil is by far the preferred cleanup technique whenever possible. Burning, on the other hand, may provide a safe, efficient and logistically simple method for eliminating oil under certain conditions. As a backup for mechanical cleanup techniques, in-situ burning can provide a useful means of eliminating large quantities of oil quickly, while avoiding the need for recovered oil storage containers. Anyone considering the use of burning should be sure that all regulatory controls have been satisfied, that the ignition and burning operations can be carried out safely, and that the temporary reductions in local air quality represent the lower of all other environmental impacts should the spilled oil not be burned.