

### Ohmsett's Propane-Fuelled Test System for Fire-Resistant Boom

J. McCourt and I. Buist  
SL Ross Environmental Research  
Ottawa, ON, Canada  
James@slross.com

W. Schmidt and D. Devitis  
MAR Inc.  
Leonardo, NJ, United States

B. Urban  
PCCI, Inc.  
Alexandria, VA, United States

J. Mullin  
Minerals Management Service  
Herndon, VA, United States

#### Abstract

A propane-fueled system for testing fire-resistant booms was installed at Ohmsett in the fall of 1998. The system exposes candidate booms to air-enhanced propane flames and waves, to reproduce a realistic *in situ* burning environment essentially equal to that of a diesel or crude oil fire. Four fire boom systems were successfully tested in 1998 in two sessions. It is envisioned that this system will be used as one phase of a protocol that will completely evaluate the performance of a fireboom, and include other parameters such as towing performance and the ability to contain hot oil after exposure to flames.

#### 1.0 Introduction

Recognizing the need for a realistic test to evaluate the performance of fire-resistant boom, the Minerals Management Service (MMS) of the United States Department of the Interior and the Canadian Coast Guard jointly funded the development of a test protocol and propane-fueled apparatus. The development took place at an outdoor wave tank at the National Research Council of Canada in Ottawa.

A prototype system was designed, built and tested in the fall of 1996 (Mccourt *et al.*, 1997). The preliminary test layout had the candidate boom deployed in a U-configuration, with the burn area (1 m by 8 m) located at the apex. A current generator at the mouth of the boom simulated towing and produced tension in the boom. The propane flow rate was 407 kg/hr, which produced a power output of 5.7 MW, or 0.7 MW/m<sup>2</sup> of water surface. This was quite low compared with the power output of Alaska North Slope crude oil (1.76 MW/m<sup>2</sup>) and diesel (2.34 MW/m<sup>2</sup>) fires (McGrattan *et al.*, 1997). Also, the current generator was unable to produce realistic tension loads without interfering with the waves in the tank. Still, the system showed promise and the work was continued.

Three major changes were implemented in 1997 (Mccourt *et al.*, 1998):

- i. the target propane flow rate was increased to 1000 kg/hr;
- ii. 375 cfm of compressed air was injected into the burn area to increase heat output and reduce smoke; and,
- iii. the boom was deployed in a line and tensioned, with fire areas on both sides.

These changes had the desired effect: tension loads on the boom were realistic, and the average total heat flux was between 110 and 130 kW/m<sup>2</sup>, which is approximately equal to that of a crude oil or diesel burn.

#### 2.0 Test System

Following the success of the 1997 tests, the system was installed at Ohmsett. The Arctic and Marine Oilspill Program (AMOP) Technical Seminar, 22nd. Environment Canada. Volume 2. Proceedings. June 2-4, 1999, Alberta, Canada, Environment Canada, Ottawa, Ontario, 439-445 pp, 1999

propane and air flow-rates were increased to provide some flexibility if higher heat levels were needed. The burner layout was also modified. Figure 1 is a schematic diagram of the system layout.

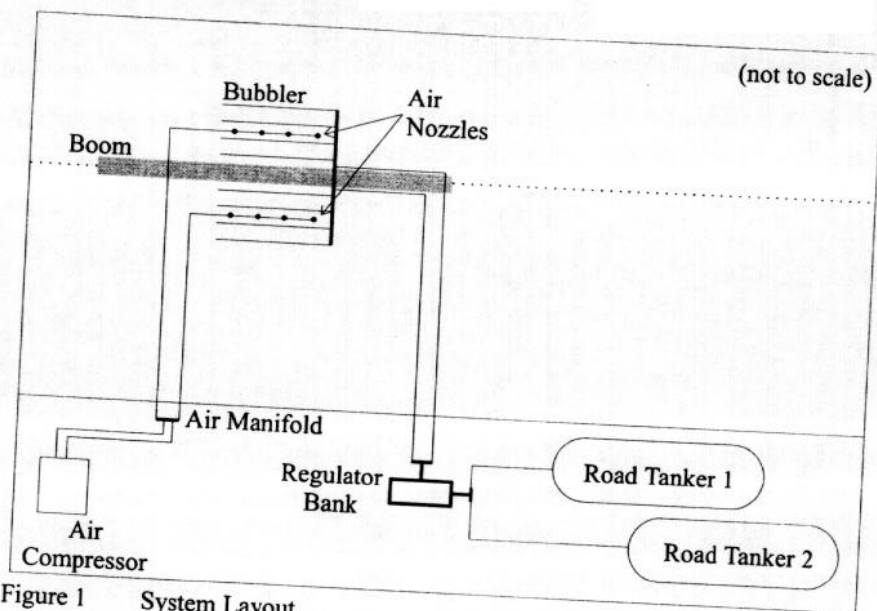


Figure 1 System Layout

Two 42,000 L road tankers supplied propane for the tests. The propane vapor was fed through a bank of regulators to reduce the pressure to the bubbler operating level of 138 kPa (see Figure 2).



Figure 2 Propane Regulator Bank

The regulator system comprises six Fisher Controls model 630-104/78 "Big Joe" regulators operating in parallel. Each regulator is rated at 4.1 MW, so the theoretical

maximum flow from the bubbler is 1800 kg/hr (1500 kg/hr equates to 20.5 MW). The propane flow rate was measured at the inlet to the regulator bank with a turbine flow meter (Omega model FLSC-62), while the pressure and temperature were measured with a thermocouple and pressure transducer, respectively.

The propane flow rate from the regulator bank outlets was controlled by ball valves on each line. The propane flows from the regulators to a header on the underwater bubbler in two 40-m sections of 2-in. hose. The header distributes propane to eight 4-m lengths of  $\frac{3}{4}$ -in. hoses that have ten or eleven 5-mm holes in their underside. There was enough back-pressure in the bubbler hoses so that the propane flow was evenly distributed over the entire burn area.

The hoses were held in place by a frame of aluminum angle that is jointed to follow the waves (see Figure 3). The frame is supported by spherical steel floats attached with chain, and can be raised and lowered in the water as needed. For these tests, the frame was submerged 1.3 m below the water in order to clear the skirts of the candidate booms. The propane was ignited by a separately-fueled pilot light attached to one side of the bubbler.

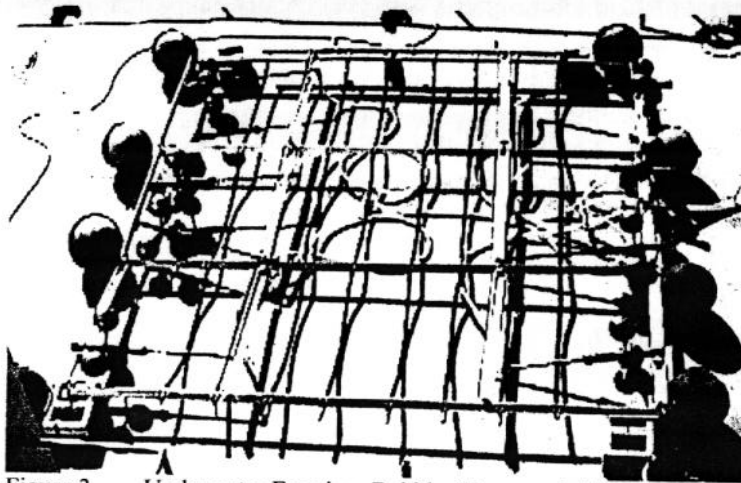


Figure 3 Underwater Framing, Bubbler Hoses and Air Nozzles

A portable compressor provided up to 600 cfm of compressed air. The air was fed to a manifold where the flow was split evenly into two equal lengths of 1-in. hose. The flow to each channel was regulated by a gate valve and measured by a pneumatic flowmeter. At the bubbler frame, the 1-in. hose splits to feed four air nozzles. The connecting hoses were of equal length to ensure that airflow was balanced approximately evenly between each of the nozzles.

The nozzles consisted of steel pipe anchored to the bubbler frame and centered in the flame zone. The pipes were supported by floatation. The pipes end 8 inches above the water in caps with six  $\frac{1}{2}$ -in. holes drilled equally spaced around their circumference to jet the air horizontally 360° into the combustion zone.

### 3.0 Test Procedure

The system was used to evaluate the performance of four fire booms. Three of

these were actively cooled blankets that were draped over a conventional inflatable boom. The fourth was a stainless steel fire boom.

The candidate booms were deployed lengthwise along the wave tank, centered over the bubbler frame (see Figure 4). The booms were exposed to three two-hour sessions of one hour of burning in waves followed by one hour of waves alone. This was to simulate the collection and burning phases of an *in situ* burn operation. The tension on the boom was monitored and adjusted as necessary to take up slack from stretching.

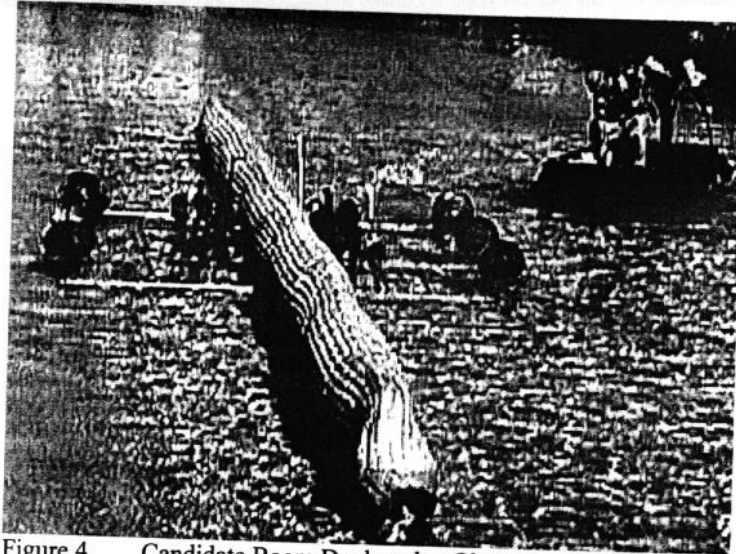


Figure 4 Candidate Boom Deployed at Ohmsett

#### 4.0 System Performance

Administrative staff at Naval Weapons Station Earle, where Ohmsett is located, were initially reluctant to allow the system to be installed; however, after viewing several test burns, the regulators agreed that the test was safe and that smoke production was well within acceptable limits (see Figure 5).

The system was capable of feeding propane at up to 1640 kg/hr, although the smoke production was deemed to be too high at this rate.

Heat output was measured by two total heat flux transducers (THFT, Medtherm model 64-20-20). Total refers to the fact that they measure both radiative and convective heat flux. Figure 6 shows the heat flux measured by the east-facing THFT in the third hour of burning with the stainless steel boom. The fluctuations in the readings are normal, and are due to the fact that the THFTs respond very quickly to changes in heat input. Data from the west-facing THFT is given in Buist *et al.* (1999).

The system was operating at the design propane flow rate of 1500 kg/hr. The mean heat flux from the east THFT was  $113 \text{ kW/m}^2$ , while the west-facing THFT measured an average heat flux of  $124 \text{ kW/m}^2$ .

At the end of the burn, the stainless steel boom was glowing cherry red. Consultation with metallurgical charts indicates that the temperature of the boom was on the order of  $900^\circ\text{C}$  (Ammen, 1980).

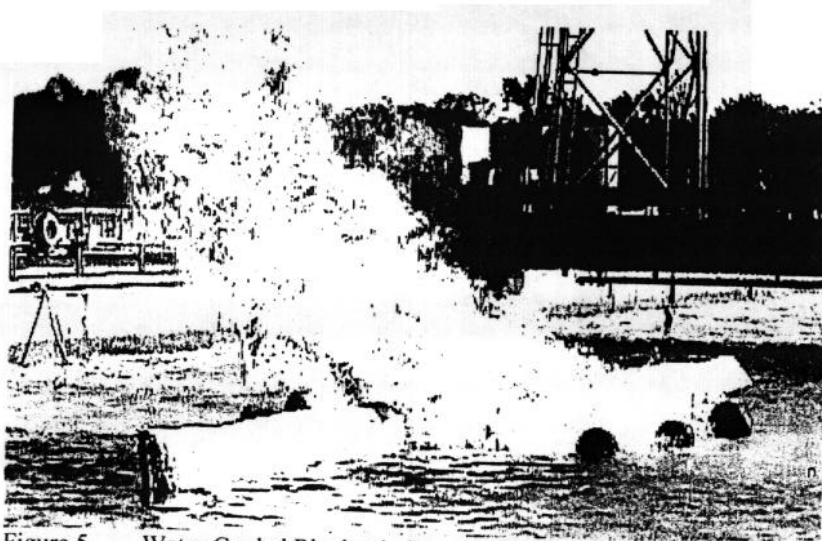


Figure 5 Water-Cooled Blanket in Propane Flames

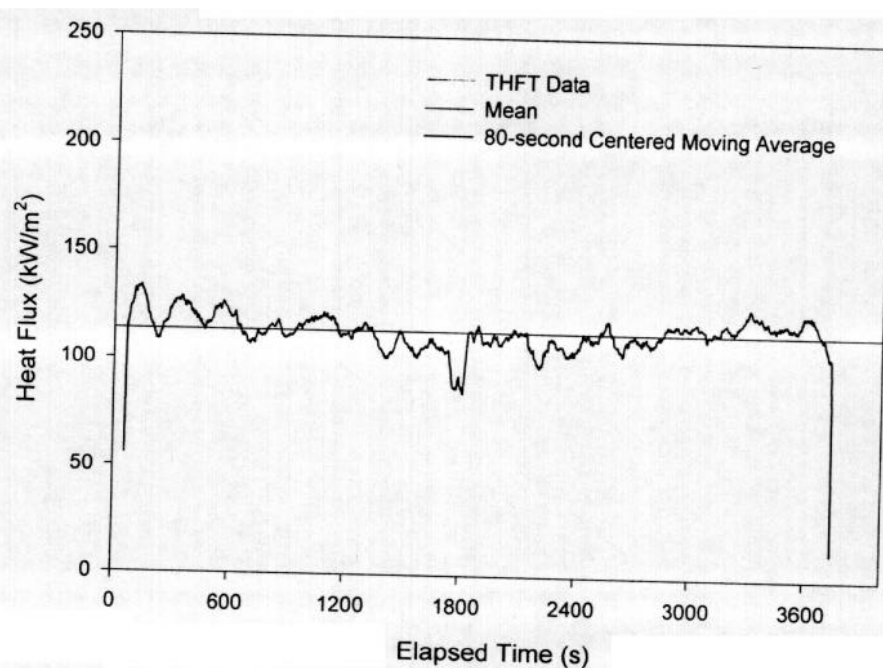


Figure 6 Heat Flux Data from Third Burn of Stainless Steel Boom Tests

### 5.0 Conclusions

At present, only one other protocol is being used to evaluate fire-resistant booms. This method uses diesel-fueled fires to simulate a crude oil fire (Walton *et al.*, 1998). Figure 7 shows a graph of the total heat flux measured during a diesel burn with the

stainless steel boom. The average heat flux appears to be about  $110 \text{ kW/m}^2$ . The temperature, as measured by thermocouples fixed to the boom surface, (see Figure 8) fluctuates in the  $900$  to  $950^\circ\text{C}$  range.

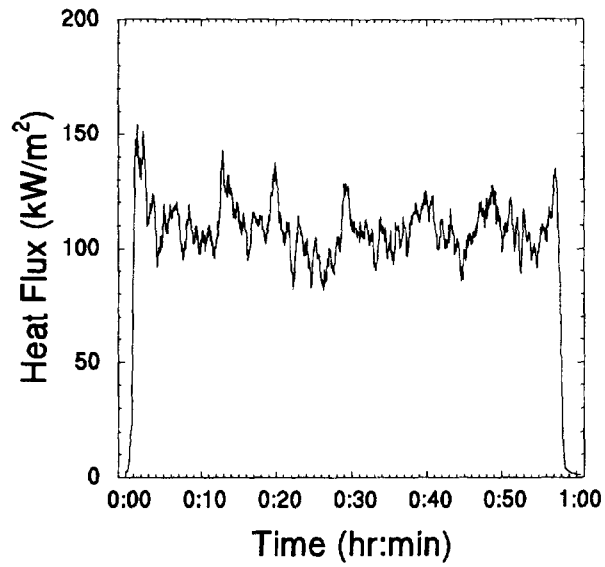


Figure 7 Heat Flux from Diesel Fire

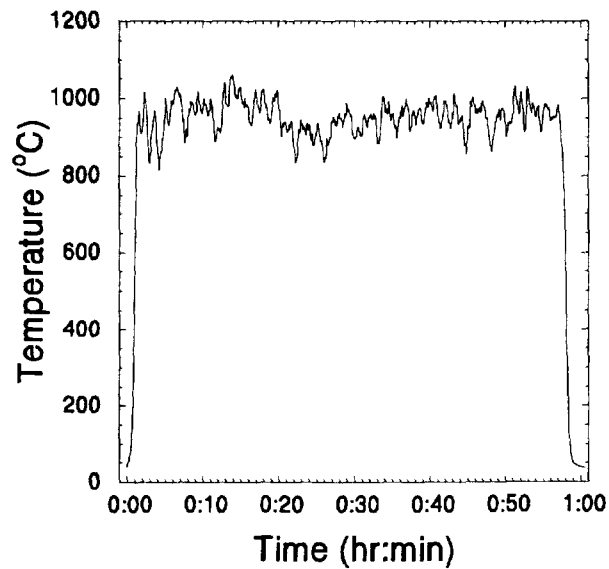


Figure 8 Temperature Measured in Diesel Fire

The heat flux produced by the Ohmsett system is, for all practical purposes, equal to that produced by the diesel fire. Visually, the propane flames accurately

simulate a crude oil fire, but have the advantages of instant fire control and low smoke production. Finally, the enhanced-propane protocol has been shown to produce the same degree of damage to a boom as an actual *in situ* burn (McCourt *et al.* 1998).

All evidence indicates that this protocol accurately simulates real *in situ* burning conditions.

## 6.0 Acknowledgements

The authors would like to acknowledge the assistance of the staff of MAR Inc., who maintain and operate Ohmsett. The authors would also like to acknowledge the Minerals Management Service and the US Navy Supervisor of Salvage for providing funding for the project.

## 7.0 References

Ammen, C.W., *The Metalcaster's Bible*, TAB Books, pp. 409, 1980.

Buist, I., S. Potter, J. McCourt, P. Lane, P. Newsom, L. Hillebrand and S. Buffington, "Re-Engineering of a Stainless Steel Fire Boom for use in Conjunction with Conventional Fire Booms", in *Proceedings of the Twenty-Second Arctic and Marine Oilspill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa, ON, 1999.

McCourt, J., I. Buist, B. Pratte, W. Jamieson and J. Mullin, "Testing fire resistant boom in waves and flames", in *Proceedings of the Twentieth Arctic and Marine Oilspill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa, ON, pp. 1997.

McCourt, J., I. Buist, J. Mullin, B. Pratte and W. Jamieson, "Continued development of a test for fire booms in waves and flames", in *Proceedings of the Twenty-First Arctic and Marine Oilspill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa, ON, pp. 505-528, 1998.

McGrattan, K.B., H.R. Baum, W.D. Walton and J. Trelles, *Smoke Plume Trajectory from In Situ Burning of Crude Oil in Alaska – Field Experiments and Modeling of Complex Terrain*, NISTIR 5958, United States Department of Commerce, National Institute of Standards and Technology, 127 p., 1997.

Walton, W.D., W.H. Twilley, J.V. Mullin and R.R. Hiltabrand, "Evaluating a Protocol for Testing Fire-resistant Oil Spill Containment Boom", in *Proceedings of the Twenty-First Arctic and Marine Oilspill Program (AMOP) Technical Seminar*, Environment Canada, Ottawa, ON, pp. 651-672, 1998.