SMALL-SCALE IN-SITU BURN TESTS TO DEVELOP OPERATIONAL PROFICIENCIES

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Abstract:
This is a non-scientific paper by an author who is an operations person. The target audience is members of the response community, more specifically those members who must be prepared to implement alternate technology countermeasures while preparing to do so on reduced training budgets. It is simply the story of how two oil spill cooperatives in the Northwest region of the United States introduced their field personnel to in-situ burning while conducting a product test of fire containment booms. Two very different styles of fire boom were deployed in open water and evaluated. Later, at a permitted training facility, the same booms were exposed to multiple test tank burns. Residual burned crude oil was recovered and the booms decontaminated. In the end, test participants and observers had developed "hands-on" in-situ burning experience, on a small-scale. Out-of-pocket costs were surprisingly minimal given the nature of the project.

Operational protocol developed for our small-scale test will be discussed in this paper as well as the logistics and costs associated with hosting such an event. The lessons learned in conducting this experiment will be shared. From the small-scale test we will try to project what we now expect to experience during a full scale in-situ burn response.

Environment Canada. Arctic and Marine Oilspill Program (AMOP) Technical Seminar, 19th. Volume 2. Proceedings. June 12-14, 1996, Alberta, Canada, Environment Canada, Ottawa, Ontario, 979-985 pp, 1996.

In-Situ Burn Policy in the Northwest

In the United States, the "Northwest Area Contingency Plan" is a multi-agency document guiding all actions during an oil spill response in the three state area of Washington, Oregon, and Idaho. This plan recognizes in-situ burning (ISB) as a potential technique in spill response. Pre-approval guidelines have been developed and published by the authors of this contingency plan in an effort to expedite the decision-making process within the Unified Command. Public outreach programs have been initiated to educate citizens on the environmental costs and benefits associated with the in-situ burning of spilled oil. From a rhetorical standpoint, with this much regulatory emphasis on in-situ burning, could there be any doubt that at some time in the future Northwest spill responders would be tasked with conducting an ISB countermeasure?

Policy-wise, in-situ burning was well on its way toward becoming a realistic option in Northwest oil spill response. Operationally, field personnel needed the opportunity to mature beyond classroom training and videos. As regulators fine-tuned the mechanism for approving in-situ burn applications in preparation for an actual incident, two Washington State oil spill cooperatives sought a means of increasing their operational proficiency to execute an in-situ burn directive.
Clean Sound Cooperative, with support from Region V of the Marine Spill Response Corporation (MSRC), designed and conducted a small-scale in-situ burn test.

Evolution of the Small-scale Test

The origin of this test came from within the Northwest Ad Hoc Equipment Committee, a response community work group that provides a regular venue to review oil spill clean-up equipment. At a Committee meeting, inventor Richard Magoon presented his Spill-Tain metal fire boom. Following the presentation, Roland Miller, President of Washington's Clean Sound Cooperative felt that there was sufficient merit in the Spill-Tain prototype to warrant an open water tow test. Months later, following completion of the tow test, Clean Sound's membership agreed that this boom was a candidate for a static burn test.

Mr. Miller took the proposal for a small-scale test burn with Spill-Tain to the Ad Hoc Equipment Committee where it evolved to another level. To optimize the evaluation, it was determined that a second fire containment boom should be included in the test. The American Marine Company agreed to participate with a section of their fire boom. The project had now reached the point where outreach within the response community could be improved by inviting the Marine Spill Response Corporation (MSRC)/Northwest Region to participate with Clean Sound Cooperative in the test. What had begun as a means of evaluating a response product grew, by its very nature, into a training exercise whereby the following objectives could be met:

- Functional integration of two separate response crews (Clean Sound and MSRC)
- Open water maneuvers with distinctly different designs of fire containment boom
- The opportunity to pump and gauge crude oil
- Experience with the ignition, proximity, and behavior of a crude oil burn
- Recovery and disposal of burned crude oil residue

Though targeted to benefit operations personnel, scientific professionals were also invited to participate in the test. Air quality monitoring was conducted by the National Oceanic and Atmospheric Administration (NOAA) Haz-Mat group and the Washington Department of Ecology. Observers from industry and government were invited to use this test as a forum for discussing implementation of in-situ burning during a spill.

Puget Sound was to be used for the open water portion of the test. For the static burn portion, an ideal test facility was found at the Washington State Fire Training Academy. This fire service training center maintained a 70,000 gallon concrete tank that had originally been constructed as an oil spill training prop. With dimensions of 69' x 53' x 2.5', the tank was fed by water from the Academy's fire main system. Effluent water from the test tank drained to the facility's oil/water separator where it was returned clean to the fire main reservoir as part of a closed loop system. Equally beneficial was the fact that the Academy held the necessary air quality permits to conduct open burning.

Development of the Test Protocol

The tests were scheduled to progress over a four day period and incorporate the following daily activities: 1.) open water tow test of both Spill-Tain and American Marine fire boom, 2.) three separate fresh water burn tests of the same section of each boom, 3.) open water tow test of the previously burned Spill-Tain boom, and 4.) three separate salt water burn tests of both types of previously burned boom. This generous schedule would allow rotation of two 12-person crews through the program. It would also provide for a rigorous evaluation of the booms.

Protocol for the open water test employed small "spill response vessels" (SRVs) towing the booms in multiple configurations. MSRC's "oil spill response vessel" (OSRV), ***Washington Responder***, served as a staging and observation platform. A static boom display was maintained on the afterdeck of the mothership where participants were able to evaluate each product's stowage and deployment characteristics. Video records were made of the SRVs towing the booms according to prearranged patterns of straight lines behind a single SRV, "J" shape between two SRVs, and in a catenary between two SRVs. An independent vessel created an artificial sea state for evaluation of the stability and articulation of the booms in a wave period.

Protocol for the test tank burns at the Washington State Fire Training Academy proceeded according to a plan that divided the crews along two functional lines: 1.) "hot" zone operations workers, and 2.) support personnel. Hot zone workers pumped and gauged oil, ignited the slick, and recovered the residual oil. Support workers provided logistics and enforced security zones. Approximately 50 people from industry and government attended as observers.

Narrative of the Burn Test

Sample sections of each style of fire boom were anchored in a rough circular pattern at opposite ends of the test tank. Interior surface area for the American Marine boom was 32 square feet while the surface area of the Spill-Tain boom measured approximately 56 square feet. Alaska North Slope Crude was pumped into each boom to a depth of 6 inches, calculated to burn for one hour. The oil was ignited using a standard highway flare fixed to the end of a pike pole. Detailed observations of the boom stability, smoke plume, burn rate, and flame characterization were recorded by a data technician. For the protection of operations personnel and to prevent the fire from spalling the concrete of the tank, firefighters with charged hose lines maintained a safety watch. The burn was allowed to progress from ignition until it self-extinguished.

At ignition, flames spread slowly and evenly across the contained surface areas of the booms. Gusty winds drafted heavy black smoke up from the fire high and away from the test area. Not long after ignition, flames associated with the Spill-Tain boom lapped over the containment area and ignited oil that had leaked from the hinged joints of the metal boom. The firefighters controlled flames outside the containment boom with water spray allowing the fire within to burn itself out.

At 28 minutes after ignition, the fire inside the Spill-Tain boom burned out. By 30 minutes, the American Marine fire was also out. The booms were declared safe to approach 15 minutes past extinguishment and residue recovery began. It was noted that the actual burn time was less than the target duration of 60 minutes. Since an oil slick burns at the rate of 0.11 inch/minute (Allen, 1994), this indicated that the pre-ignition volume of oil must have been less than the 6 inch design amount. The original method of measuring the oil depth with a tankerman's sounding tape was flawed and had to be amended.

Prior to refueling the booms for the second test event, the burned oil residue was removed from the tank. This residue resembled a taffy-like asphalt emulsion that proved to be extremely difficult to handle. Sticky and viscous, the residue defied recovery with sorbent snare and was best removed using pitchforks and buckets. Following recovery of the burned residue, the manufacturer of the Spill-Tain boom attempted to reduce its leakage by eliminating an anchor float section. Both booms were checked for position and refueled to the second test's target depth with 9 inches of crude oil. To improve the accuracy of the oil measurement, two alternate methods were tried: 1.) use of a clear column bailer to capture the depth of the oil/water interface, and 2.) sorbent wrapped rebar passed under the water upward to the slick's surface. Of the two methods, it was felt that the rebar method yielded a more accurate result.

Before ignition of the second test, it was noted that the Spill-Tain boom was rapidly leaking oil from the hinged joints. Though the design depth of the slick was to be 9 inches, the Spill-Tain boom never held more than 7 inches because of the leakage. Ignition for the second burn test followed the protocol employed on the first test. Targeted combustion time was 1.5 hours.

The second burn test was marked by immediate oil seepage through the hinged joints of the Spill-Tain boom and later seepage through the fabric joints of the American Marine boom. Firefighters were required to extinguish flames of fugitive oil slicks that burned too close to the concrete tank walls. After 50 minutes, the Spill-Tain slick had burned down to its extinguishing thickness within the boom. At the 55 minute mark, the fire in the American Marine boom was also out. The residue remaining after the second test was substantially different from that of the first test. Both booms experienced more complete combustion characterized by less tar-like emulsion and more of a mildly brittle product resembling heavy cellophane. Oil that had escaped the booms remained viscous and tarry.

Following the second burn, test sponsors and boom manufacturers met. Those present concurred that while each boom was structurally sound, the volume of oil leaking from the joints was unsatisfactory. The in-situ burn test was evolving into a firefighting exercise. As a result, the remainder of the scheduled tests were canceled.

Each manufacturer examined his boom for research purposes. Upon release, the American Marine boom was disposed of as a solid waste. An effort was made to decontaminate on-site the stainless steel Spill-Tain boom, but the burned oil residue upon it was unaffected either by citrus degreaser or high pressure hot water. Mr. Magoon later baked the Spill-Tain boom in an industrial engine degreasing oven which rendered it clean enough to undergo a successful, sheen-free, open water tow test.

Two consecutive freshwater burn tests were conducted on both the Spill-Tain and American Marine fire booms. While this was significantly short of our product performance goal of 3 freshwater burn tests and 3 saltwater burn tests, the operational goals of the event were met.

Summary of Test Data

While not attempting to imitate a scientific experiment, a data technician maintained an official log of elapsed time and crude oil measurements throughout the burn test. A summary of that data follows. It should be noted that difficulty was experienced in accurately measuring the volume of pre-combustion oil contained in each boom. Referring to **Table I** below, to provide validation for the data listed as "Volume of Oil Consumed," two methods of estimation were used. These results were then compared to the actual volume taken from the storage tank supplying crude oil to burn. As such, 596 gallons were consumed during all the burn tests. This indicates that the "Estimate By Measure" consumption figure may have been overstated by 20 percent. The 496 gallon estimate "By Combustion Time" correlates quite well with the actual volume taken from the storage tank particularly if the 80 gallons of residue is added back as part of the original volume.

Table I

Data		American Marine	Spill-tain
Interior Surface Area		32 square feet	56 square feet
Burn Test Times	Test #1	30 minutes	28 minutes
	Test # 2	55 minutes	50 minutes
Estimated Oil Consumed			
(method: by sounding oil depth)	Test #1	140 gallons	208 gallons
	Test # 2	180 gallons	242 gallons
Estimated Oil Consumed			
(method: by combustion time of 0.11 inches/min)	Test #1	67 gallons	110 gallons
	Test # 2	123 gallons	196 gallons

Actual Crude Oil Consumed (Both Booms / Both Tests):
596 Gallons

Estimated Post-Combustion Residue (Both Booms / Both Tests):
80 Gallons

<u>Summary of Burn Test Costs</u>

For oil spill cooperatives that are staffed with full time crews, open water tow tests can easily be incorporated as part of their operating budget. However, significant costs can be assumed in conducting an in-situ test burn. Following below is a summary of the out-of-pocket costs incurred in for a full day of tests. These costs appear artificially low. This is due to donated labor and equipment provided by Clean Sound Cooperative and MSRC. If these costs were added to the costs shown, the actual burn test could have exceeded $25,000 (U.S.).

Administrative Supplies	$51
Operational Supplies	$884
Trucking (Crude Oil)	$1042
Test Facility Rental	$800
Crude Oil (Consumed)	$785
Residue Disposal	$588
Total Out-Of-Pocket Costs	<u>$4150</u>

<u>Lessons Learned</u>

The primary benefit of the small-scale test was the ability to integrate operations personnel from two distinct response organizations and train them, in a controlled environment, to burn crude oil. The major lessons learned during the test pertained to pre-combustion volume estimation, oil slick ignition, and residue recovery.

Regardless of the amount of science associated with the test, virtually everybody wants to know the volume of pre-combustion oil introduced into the boom and the volume of residue recovered. We found that it was very difficult to gauge the depth of crude oil contained in the booms. The three methods employed (sounding tape, clear column bailer, and sorbent wrapped rebar) created an element of doubt in their accuracy. In retrospect, the measurement would have been accurate had we first transferred the crude oil into a small tank of known volume and filled the booms from that "measuring cup."

As responders, we were quite concerned over the volatility of the crude oil when exposed to a source of ignition. Historically, we had all been trained to ignite an in-situ burn with a heli-torch. The small-scale test proved that a burn could safely be ignited at close proximity by a hand-held ignitor. Indeed, the fire spread slowly and evenly across the slick after exposure to the highway flare. We now feel confident that an in-situ burn at sea can likewise be safely ignited by a hand-tossed device from a small boat in close proximity to the contained oil.

Finally, we were totally unprepared for the viscosity of the burned oil residue. The byproduct of four separate oil fires throughout the day ranged in consistency from taffy to crispy cellophane. This outcome generated a great respect for the cleanup operation following an in-situ burn event. For the next residue recovery operation, we will abandon viscous oil snares altogether and rely solely on pitchforks and possibly even sludge pumps.

Conclusion

The small-scale test gave participants a high degree of confidence in what to expect should they ever be called to execute a full scale in-situ burn. We believe burning is an effective technique in removing spilled oil. However, it is one of many viable techniques and should be treated as a contributing countermeasures option. Managing a properly contained burning oil slick can be done safely. Yet we learned that much refinement still needs to be done with fire containment booms. Recovery of the burned oil residue can be a daunting task. While static tank burns may yield incomplete combustion, we now would expect to assign more powerful resources to the recovery of residue than had previously been thought. As a result of the small-scale test, Clean Sound, MSRC, industry, and government personnel who participated are now better prepared to make decisions regarding in-situ burning.