A STUDY ON THE EFFECTS OF OIL FIRES ON FIRE BOOM EMPLOYED DURING THE IN-SITU BURNING OF OIL

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SUMMARY:

For over 10 years scientists have studied the effects of in-situ burning of oil on air and water quality and potential related health issues. The recent Newfoundland Offshore Burn experiment, conducted by Environmental Canada, was the culmination of several years of work. The results of this experiment found that "emissions from the in-situ oil fire were lower than expected and all compounds and parameters measured were below heath concerns at 150 meters from the fire". P.A.H.'s were found to be lower in the soot generated from the fire than in the starting oil prior to the fire. The conclusion reached was that the environmental benefits resulting from the burning of oil spills far outweigh the potential air pollution caused from the smoke. These findings now open the door on the use of in-situ burning of oil as a major tool to be used to mitigate environmental damage from oil spills.

As a result of these and other test findings, Region 6 of the Regional Response Team (made up of the U.S. Coast Guard, The Minerals Management Service, The Department of Environmental Quality, The Environmental Protection Agency, and other state and federal agencies) has pre-approved the use of in-situ burning of oil spills for offshore Louisiana and Texas. Other parts of the country and other countries are evaluating the use of in-situ burning to combat oil spills. Now that

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the scientific community has weighed the environmental costs and benefits of in-situ burning it is time to address the operational and procedural issues.

The present study evaluates the effects of oil fires on fire booms. This paper will present the results of over a dozen oil burn tests, including the effects of various different insulation systems employed to protect oil booms from the intense heat they are exposed to in oil fires. Thermocouples were used to analyze the temperatures generated by the oil fire and the heat transfer from the fire to the boom. Automated Infrared Imaging Temperature Measurements were also used to obtain transient temperature distribution of oil fires. This technique was developed by Dr. Kozo Saito at the University of Kentucky.

BACKGROUND TESTING:

There have only been a few government sanctioned in-situ test burns conducted in the U.S. and Canada over the past several years. These have been conducted primarily to evaluate the effects of in-situ burning on air quality. Nevertheless, fire booms were employed in these tests to contain the oil while burning and we can learn something about their ability to withstand the high temperatures of the oil fire from these tests.

Several tests have been performed at the Mobile, Alabama test site. These tests were conducted under the supervision of the U.S. Coast Guard, The Minerals Management Service and The National Institute of Standards & Technology. Temperatures in the fire were monitored and reached 2,000° F. Three manufacturers provided the fire boom that was employed in the test burns at this facility. One manufacturer, 3M, provided a solid float fire boom. Two other manufacturers, Kepner Plastics and Oil Stop, Inc. provided air filled or inflatable fire booms for other test burns at this facility. Two of the three booms survived the test burns.

Another in-situ burn experiment was conducted under the supervision of Environmental Canada in Newfoundland, Canada during 1993. Several American government agencies including The U.S. Coast Guard, The Minerals Management Service, The U.S. Environmental Protection Agency and The American Petroleum Institute participated in witnessing this test. Again, this test was primarily aimed at evaluating the effects on air quality resulting from in-situ burning. The 3M solid float fire boom was used to contain the oil in this test. Thermocouples were attached to the fire boom to monitor temperatures. Temperatures were found to be around 1750° F at the top of the boom and in the 400° F range at the lower portion of the boom's flotation near the waterline "Researchers indicated that the boom did not hold up as well as expected". Researchers inspected the boom after the burn and found that the "middle tension member had lost three of its flotation logs. The boom was in fair condition but could not have been safely used for another burn."

ONGOING TESTING:

Oil Stop, Inc. has conducted over a dozen tank burns to further evaluate the effects of oil fires on fire boom. These test have been aimed at monitoring the temperature in the oil fire, as well as the heat transfer to the boom itself. Thermocouples were placed in the fire, on the surface of the boom and inside the boom. Automated Infrared Imaging Temperature Measurements were also used to obtain the transient temperature distribution of the oil fires. Oil Stop's inflatable fire boom was used during these tests to evaluate its ability to withstand the high temperatures of the oil fire. Various reflective and insulating materials were used to test their effectiveness at reducing the internal temperature of the fire boom.

Fire temperatures were found to reach 2,000° F, while water temperatures reached 212° F. External boom temperatures reached 1,700° - 1,800° F. Infrared thermography was used to measure the radiant characteristics of the crude oil fires. Most of the flame surface was shielded by smoke produced by the fire. However, most of the radiation came from the flame base which was continuously visible and from intermittent flame spots on the smoke layer. Hot spots in the fire moved randomly as winds shifted.

Many of these tank tests were conducted to evaluate different insulating materials used to protect the inflatable boom underneath. Refractory materials, which are ceramic based, were found to withstand the high temperatures of the fire, however they lost tensile strength and became brittle after being subjected to the high temperatures. The conclusion was reached that ceramic materials should not be subjected to tensional loads during in-situ burns or they would be susceptible to failure. Multiple layers of ceramic material improved the longevity of the inner layers. When waves and salt water were introduced during the burn, it was found that outside layers were susceptible to embrittlement.

Temperature measurements on the boom surface were found to be highest at the top of the booms' flotation member. Temperature dropped by 20 to 30% at 90° from the top of the flotation chamber. This led us to conclude that, to be effective, insulation should be increased in the hottest area at the top of the float. The Oil Stop inflatable boom withstood four hours of continuous burning and was then removed from the test tank for evaluation. Each section of boom was dissected for careful inspection.

Underwater tubes were added to the inflatable boom to allow for heat transfer between the inside of the boom and the water below the boom. Air was allowed to circulate through these tubes. The internal temperature of the boom was monitored and was reduced by 20% to 25% as a result of the heat transfer with the cool water below. The external boom fabric evidenced significantly less degradation as a result of this reduced heat. These findings indicate that it may be possible to cool the boom using sea water and that this would greatly extend the life of fire booms. The opportunity exists to use these finding to create new and improved fire boom technology

CONCLUSION:

In-situ burning of oil represents an extremely efficient manner to get rid of spilled oil at sea. According to studies conducted by Allen & Ferek (1993), an operating fire boom unit which includes 300 to 500 feet of fire boom can eliminate 15,000 barrels of oil per day. Based on their calculations, the estimated costs associated with in-situ burning amounts to 20% of the costs associated with mechanical oil recovery. It is logical therefore to consider the use of in-situ burning of spilled oil as an alternative to mechanical recovery under favorable conditions. Now that the concerns over air quality have been resolved, it is appropriate to turn the industry's attention to the operational aspects of in-situ burning to facilitate good technical information related to the operation capabilities of fire booms. It is imperative that offshore tests be conducted in a controlled and scientific environment to gather more data about available technology employed to contain spilled oil while burning and to further develop new technology.

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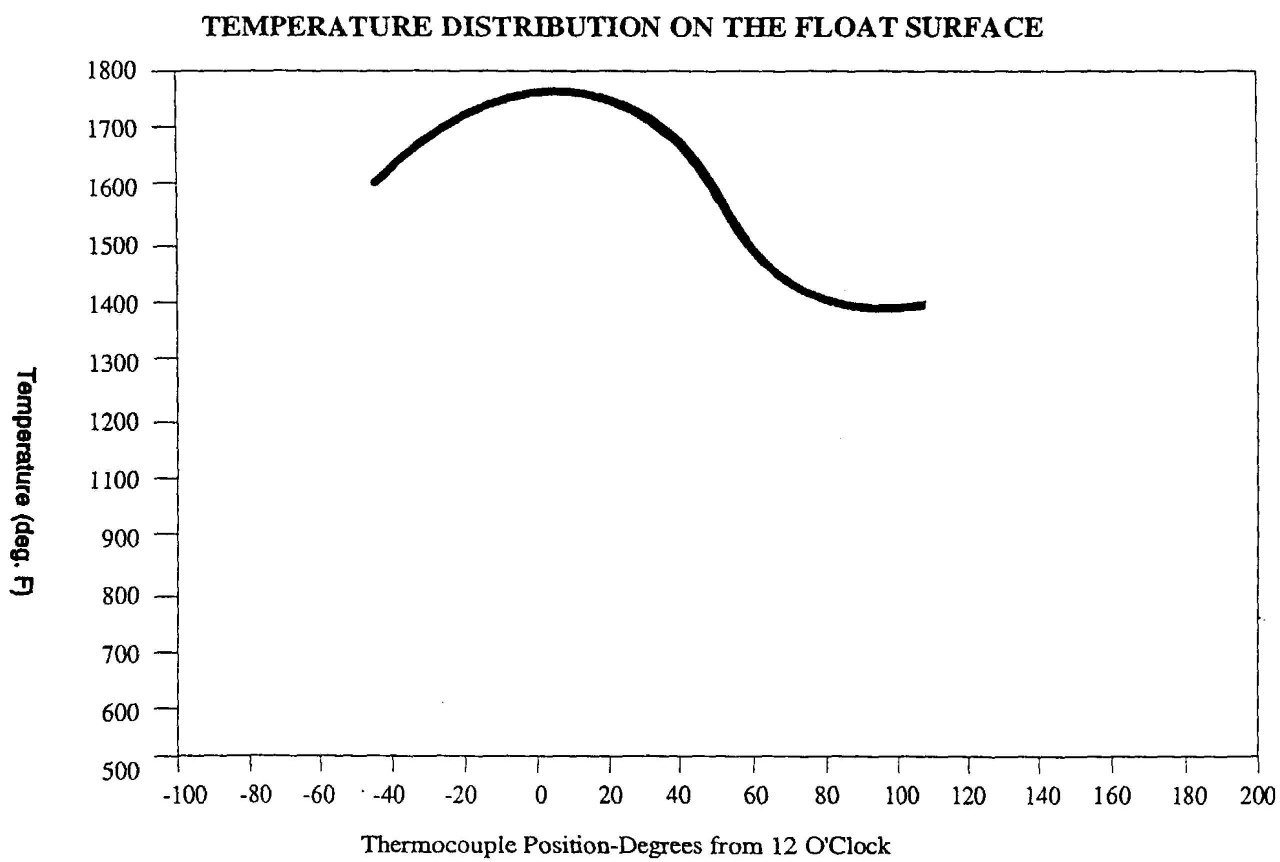
TEMPERATURE DISTRIBUTION ON THE FLOAT SURFACE
1800
1700
1600
1500
1400
1300
1200
1100
900
800
700
600
500
Temperature (deg. F)
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
140
160
180
200
Thermocouple Position-Degrees from 12 O'Clock

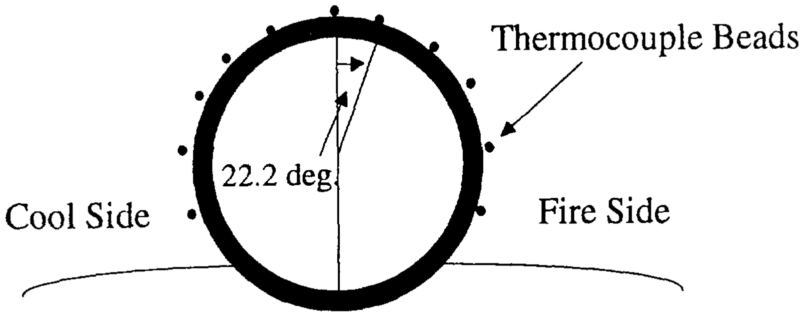

Figure 2: Thermocouple Locations on the float surface