Recent Oil Spill Response Research Projects:

1. Comparing Oil Behaviours
2. Linear Augmented Fire Boom
3. Decanting Practices and Regulations Review

Steve Potter
SL Ross Environmental Research Limited
Ottawa, Canada
Steve@SLRoss.com

Introduction: Background

- Royal Society of Canada (RSC) established an Expert Panel in response to a request from the Canadian Energy Pipeline Association (CEPA) and the Canadian Association of Petroleum Producers (CAPP).
- The Expert Panel, composed of international specialists on spilled oil chemistry, behaviour and toxicity, reviewed the current science relevant to crude oils spilled into Canadian waterways.
- Multiple data gaps were identified. This project was developed to address multiple short-term needs addressing chemical composition, properties, and behaviour of spilled oils including diluted bitumen blends.

1. Comparing Oil Behaviours: Conventional and Unconventional Crude Oils

Introduction: Primary Tasks

- Multiple Laboratory- and Meso-scale tests were designed and selected to measure oil composition and physical properties of a range of oils.
- Testing and analysis determine how those properties change when oils are subjected to evaporation, interactions with suspended particles, weathering in dynamic conditions on fresh and salt-water.
- Additional testing involving adhesion comparison evaluations on beach media in a wave tank are included.

Test Liquids – Selected Oils

- A total of 14 oils were selected for this study.
- Range in composition from very light condensates, very light crudes, medium crudes and heavy crudes, as well as a range of “unconventional” diluted bitumen blends

1. Comparing Oil Behaviours: Conventional and Unconventional Crude Oils

Laboratory-scale tests

- Spill-Related Property Tests
  - Standardized analysis of the physical and chemical properties of fresh and artificially weathered crudes for use in spill behaviour modeling.
  - Comparison of weathering (evaporation) methods, including wind tunnel (thick film - 2 cm, thin film - 1.5 mm) and a Rotovap weathering methodology (80°C, constant movement within weathering rotational flask).

  - Tests to quantify the interaction between the subject oils and suspended particles (Oil-particle aggregate formation).

Meso-scale tests

- Recirculating flume weathering tests
  - 5 m x 2 m footprint, with a 0.5 m channel
  - Stainless steel construction (insulated)
  - Water depth 1.0 m
  - Temperature (0°C, 20°C)
  - Water salinity (0, 35ppt)
  - Thrusters, fans, UV light, waterfall
- Allows more realistic behaviour of environmental conditions

Meso-scale tests

- Wave tank – shoreline adhesion tests
  - 1.2 m x 11 m footprint
  - Marine grade aluminum construction (insulated)
  - Water depth up to 1.2 m
  - Active and passive heat shields
  - Fume hood with 200 m^3/min fan
    - (primarily used for burn tests)
  - Computerized wave generator
- Allows extended time testing using consistent and repeatable waves

1. Comparing Oil Behaviours: Conventional and Unconventional Crude Oils

Project Status

- Experimental work scheduled for completion in the next few weeks
- Data analysis is ongoing
- Report expected later in 2019

Acknowledgement: Funding provided by the Canadian Energy Pipeline Association (CEPA) and the Canadian Association of Petroleum Producers (CAPP).

2. Linear Augmented Fire Boom

Introduction: Background

- In-situ burning is an effective response option for oil spills. Smoke plume, burn residues, and black carbon soot from unburned oil and incomplete combustion are identified drawbacks.
- Federal agencies, including the Bureau of Safety and Environmental Enforcement (BSEE)
- The restricted supply of adequate air to the enter of a burning slick contributes to the incomplete combustion issue
- Historical research has included :
  - High Volume/Low Velocity Diffusers
  - Subsurface Air Bubblers
  - Compressed Air Injection
  - Hybrid pump-and-burn floating burner using compressed air within a short stack

2. Linear Augmented Fire Boom

Introduction: Primary Tasks

- Bench and meso-scale tests were designed to investigate burn geometry and layout, and supplement the air supply during in-situ burning.
- Multiple tests at the bench scale are included which address different burn footprint aspect ratios plus compressed air injection configurations.
- Based upon results of bench-scale testing, testing at the meso scale is conducted using the configuration that produced the most efficient burns

2. Linear Augmented Fire Boom

Bench-Scale Testing

- Testing is conducted at the SL Ross wind/wave tank
- Floating sheet metal models of fire boom are fabricated and placed in the tank
  - Each of 3 models had an area of approximately 0.16 m^2
  - Each model had a different aspect ratio of 1.5:1, 3:1 and 6:1
  - Compressed air nozzles were positioned around the perimeter of the models, and could be altered to supply air at 90° or 45° to the vertical.

2. Linear Augmented Fire Boom

Bench-Scale Testing

- Burns were conducted on fresh ANS crude oil.
- Burn rate and burn efficiency were measured and calculated.
- Soot from each burn was collected by simple isokinetic stack sampling using a vacuum pump to draw soot and gases through a pre-weighed filter
- A total of 38 burns were conducted, varying air flow rate, wave condition, nozzle angle, and boom aspect ratio

Comparison of fire boom models with different aspect ratios

Meso-Scale Testing

- Testing is conducted at the Cold Regions Research and Engineering Laboratory (CRREL) located in Hanover, NH
- Design of test cell used 50-foot section of commercially available fire boom which was modified:
  - adjustable structural components that could hold it in rectangular shapes of different aspect ratios in waves
  - compressed air nozzles with compressed air lines
  - Each of three configurations had an area of approximately 3.4 m^2
  - The configurations consisted of aspect ratios of 1:1, 4:1, and 9:1 which would fit in the CRREL wave tank (6 m x 2.4 m)
  - The air nozzles could be oriented at 45° or 90°, or combined for 135° from the vertical.

2. Linear Augmented Fire Boom

Meso-Scale Testing

Wave control hut =>

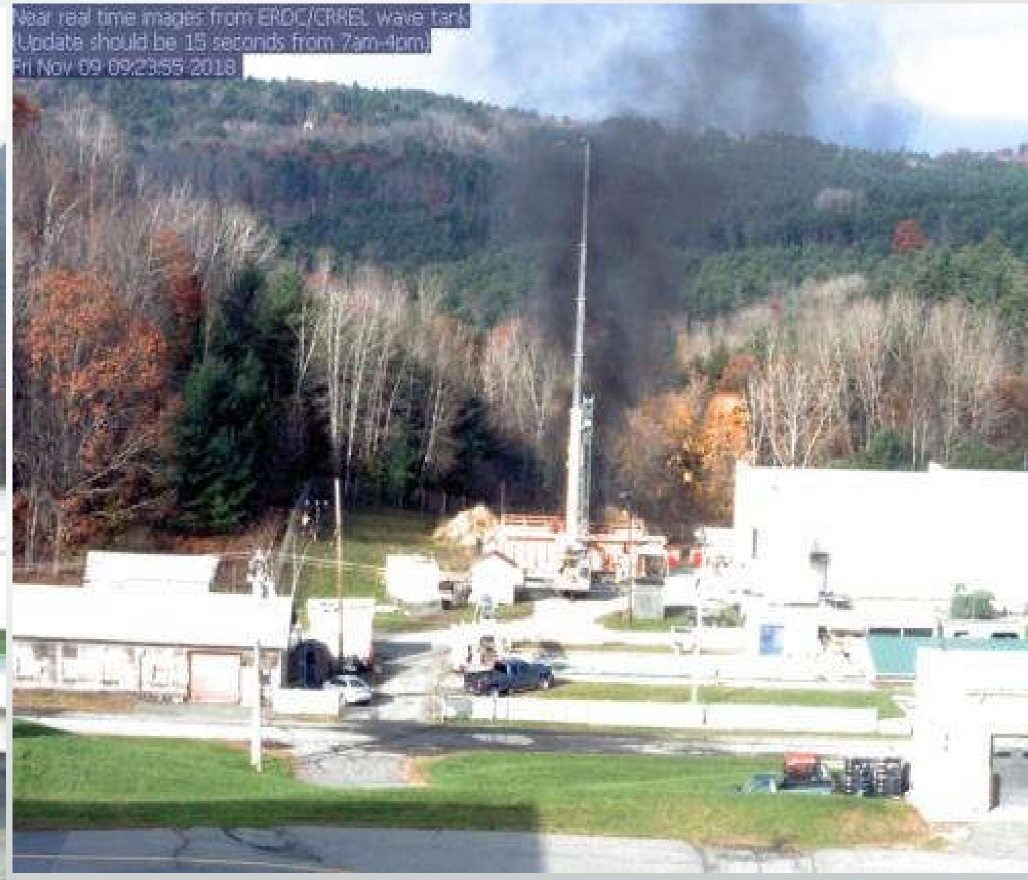
185 cfm air compressor=>

2. Linear Augmented Fire Boom

Meso-Scale Testing

- Burns were conducted on fresh ANS crude oil.
- Burn rate and burn efficiency were measured and calculated.
- Apparent density of soot emissions was observed visually, and measured using the Virtual Ringlemann App to obtain the Ringlemann number (used to obtain a rough approximation of smoke density or opacity from a stack) of the smoke plume.
- Emissions from each burn were collected by USEPA using an EPA instrument system suspended from a crane and maneuvered into the plume. Target compounds included CO, CO_2, PM2.5, total carbon, plus additional compounds.
- A total of 15 burns were conducted, varying air flow rate, wave condition, nozzle angle, and boom aspect ratio.


Near real time images from ERDC/CRREL wave tank
(Update should be 20 seconds from 8am-4pm)
Mon Nov 05 15:39:33 2018


Near real time images from ERDC/CRREL wave tank
(Update should be 15 seconds from 7am-4pm)
Fri Nov 09 09:23:55 2018

2. Linear Augmented Fire Boom

Project Status

- Experimental work completed in November 2018
- Data analysis is complete
- Report is at draft stage. Final report to be issued soon.

Acknowledgement: Funding provided by the Bureau of Safety and Environmental Enforcement (BSEE), U.S. Department of the Interior, Washington, D.C.

Introduction: Background

- Oil spills have the potential to cause significant negative impacts on the environment
- Mechanical recovery operations typically use booms to contain and thicken the oil slick, followed by skimmers to recover the product.
- Offshore skimmers often recover a large amount of water (both emulsified and free phase) as sea conditions are often less than ideal.
- Recovered water can dramatically reduce available temporary storage space, and may result in premature stoppages when storage capacity is reached until offloaded or alternate storage can be acquired.

Introduction: Background

- Decanting is the process of draining off settled-out water to increase the available storage capacity for recovered oil.
- Conventional decanting involves a gravity separation of oil from water and a discharge of that water which may exceed local and international water quality standards.
- This can lead to the unintended consequence of forcing skimming operations to be less effective, and make it more difficult to recover weathered oil.
- The aim of this review was to examine existing regulations, practices, and complementary technologies, and recommend a path forward to enable the use of decanting as an Alternative Response Measure (ARM) for oil spill response in Canada.

Regulations and Positions Reviewed

- Information on national and international regulations was collected from Canada, US, UK and Australia as well as International organizations :
  - International Maritime Organization (IMO): The MARPOL standard = 15 ppm, but for spills that occur in national waters, the decision to allow the use of decanting falls to the country in question.
  - Canada: The current regulatory regime impedes the use of alternative countermeasures, including decanting, even when there is a net environmental benefit from their use.
  - US: There are 13 Regional Response Teams (RRTs) and their approaches to regulating decanting vary – 9 RRTs include decanting-related policies in their Regional Contingency Plans.
  - UK: No specific guidance on the use of decanting during spill response was found.
  - Australia: The use of decanting is permitted, on a case-by-case basis, upon approval from the relevant authority.
  - Other non-governmental organizations with relevance to oil spill response, such as industry groups and spill response organizations.

Technologies Reviewed

- Technologies that may help lower the concentration of dissolved or mixed hydrocarbons in a decanted stream must be relatively simple to operate, have a reasonably high throughput, and be able to tolerate the presence of debris without incurring significant downtime
  - Automated decanting control system
  - Emulsion-breaking chemicals
  - Enhanced physical separation
    - Membrane separation
    - Hydrocyclones

3. Decanting Practices and Regulations Review

Conclusions

- While the MARPOL Annex I sets up an oil discharge standard of 15 ppm, it does allow individual governments to authorize decanting in specific oil spill combating situation. Gravity separation alone will not likely produce decanted water that would meet the MARPOL standard.
- Decanting is not currently permitted in Canada (according to the Canada Shipping Act, 2001, and the Canadian Environmental Protection Act, 1999).
- Present state of regulations in the US and Australia predominantly requires approval from regulators, which happens on a case-by-case basis. The exception is RRT 10 in US (Pacific Northwest), which has pre-authorized decanting for most heavy oils during the first 24 hours of a spill.
- In US, regional guidelines for the disposal of contact water in inland, ocean, and coastal waters have been developed by some jurisdictions.

Conclusions (2)

- Existing technologies can reduce the concentrations of oil in the discharged water, but many are not suitable for use in a marine, spill-response environment.
- Hydrocyclones, due to reasonable throughput capabilities and simple operation, appear to be the most promising technology for ship-board use; however, this technology is unlikely to produce effluent that meets the MARPOL standard, because it addresses only free-phase oil and not dissolved oil concentrations.
- A process train involving more than one technology may be successful, i.e., applying a bulk separation step (gravity separation or hydrocyclone) followed by a polishing step (membrane filtration or adsorption) once most of the oil has been removed.
- The primary disadvantages of a multi-step process are increased complexity and greater cost (capital costs and operational costs).

3. Decanting Practices and Regulations Review

Recommendations

- It is recommended that changes be made to legislation in Canada that would clarify options and permit (a) responders to legally decant settled-out water; and (b) the person locally in charge of response operations to make timely decisions and to circumvent delay involved in seeking a special dispensation from the relevant authority.
- Suggested conditions for decanting include:
  - (a) the skimmer vessel is operating at a remote location;
  - (b) there are logistical issues related to continued oil recovery;
  - (c) limited decanting will be permitted solely for the purpose of maximize the storage capacity to recover oil spillage;
  - (d) the on-scene decision should be made based on the application of NEBA;
  - (e) compliance with decanting guidelines;
  - (f) continuous monitoring should be performed to ensure discharge will be immediately ceased upon observation of increased oil content;
  - (g) the granting of exemption is very much more of an exception than a rule, and may only be applied in specific cases.
- Further research on the suitability of hydrocyclones, along with filtration techniques that can impact dissolved oil and be used in a process train for shipboard use is recommended.

3. Decanting Practices and Regulations Review

Project Status

- Work completed in 2018
- Final report issued

Acknowledgement: Funding provided by Environment and Climate Change Canada

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QUESTIONS?

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