NRT SCIENCE AND TECHNOLOGY COMMITTEE

Fact Sheet: Residues from *In situ* Burning of Oil on Water

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This fact sheet provides guidance on the residue produced from *in situ* burning (ISB) of oil on water. It is part of a series of fact sheets that the NRT S&T Committee has produced on ISB-related topics. It is intended to assist Regional Response Teams, On-scene Coordinators, and other regional and local staff involved in planning and implementing marine/open water ISB.

Summary

The small amount of residue from *in situ* burning (ISB) of oil on water can pose environmental concerns, particularly if they sink. Based on laboratory tests, it is possible that, for about 40-60% of the crude oils worldwide, the burn residues may sink. However, whether lab tests apply to large-scale spills is not known. Burn residues have little to no acute aquatic toxicity. The greatest impacts would likely be to the benthos from smothering; impacts for most applications would be very localized because of the small volumes generated and dispersal by currents.

Background and Status of Knowledge

Residues of oils burned in laboratory tests in the 1970-80s floated, probably because of the small scale and thin oil thicknesses used in experiments. The 1991 *Haven* spill, where large amounts of heated and burned oil residue sank[5], stimulated research on the density of burn residues.

Results from recent larger-scale laboratory and meso-scale field tests identify the most important factors determining whether an ISB residue will float or sink as:

1) Water density

The density of fresh water is 0.997 g/cm^3 at 25°C, whereas sea water is 1.025 g/cm^3. Burn residues which are denser than the receiving water are likely to sink.

2) Density of the starting oil

Correlations between the density of laboratory-generated burn residues and oil properties predict that burn residues will sink in sea water for oils with an initial density greater than about 0.865 g/cm^3 (or API gravity less than about 32°), or oils with a weight percent distillation residue (at >1000°F) greater than 18.6%. Using this correlation for 137 crude oils, 38% are predicted to sink in seawater, 20% may sink, and 42% will float[6].

3) Residue Thickness

Residues from burns of thick crude oil slicks are more likely to sink compared to burns of thin slicks of the same crude because the higher molecular weight compounds concentrate in the residue as the burn progresses.

Rules of thumb[2] for predicting residue thickness are:

- for unemulsified crude oil up to 10-20 mm thick, residue will be 1 mm
- thicker slicks result in thicker residues, residues will be up to 3-6 mm
- emulsified oils can result in much thicker residues
- for light/medium refined products, residue will be 1 mm regardless of slick thickness

Residue thickness also affects cooling rates. When burn residues sink, they do so only after cooling. Models of cooling rates predict that ambient water temperature will be reached in less than 5 minutes for 3 mm thick residues, and in 20-30 minutes for 7 mm thick residues[6].

Characteristics of Burn Residue

Physical Properties

Physical properties of burn residues vary, depending on burn efficiency and oil type. Efficient burns of heavy crudes generate brittle, solid residues (like peanut brittle); residues from efficient burns of other crudes are described as semi-solid (like cold roofing tar); inefficient burns generate mixtures of unburned oil, burned residues, and soot which are sticky, taffy-like, or semi-liquid.

Many factors affect burn efficiency, including original slick thickness, degree of emulsification and weathering, areal coverage of the flame, wind speed, and choppy waves. Removal efficiencies are expected to exceed 90% of the collected and ignited oil for efficient burns.

Environmental Effects

Toxicity:

Chemical analyses of burn residues show relative enrichment in metals and the higher molecular weight PAHs, which have high chronic toxicity but thought to have low bioavailability in the residue matrix. Bioassays with water from laboratory- and field-generated (NOBE) burn residues of Alberta Sweet Mix Blend showed little or no acute toxicity to sand dollars (sperm cell fertilization, larvae, and cytogenetics), oyster larvae, and inland silversides[3]. Bioassays using NOBE burn residues showed no acute aquatic toxicity to fish (rainbow trout and three-spine stickleback) and sea urchin fertilization[1]. Bioassays using laboratory-generated Bass Strait crude burn residue showed no acute toxicity to amphipods and very low sublethal toxicity (burying behavior) to marine snails[4].

Physical Impacts:

Localized smothering of benthic habitats and fouling of fish nets and pens may be the most significant concern when semi-solid or semi-liquid residues sink. At the *Honan Jade* spill, burn residue sank in 2 hours and adversely affected nearby crab pens[5]. All residues, whether they float or sink, could be ingested by fish, birds, mammals, and other organisms, and may also be a source for fouling of gills, feathers, fur, or baleen. However, these impacts would be expected to be much less severe than those manifested through exposure to a large, uncontained oil spill.

Ongoing Research

The Minerals Management Service, Department of the Interior, is funding two research studies to assess the suitability of Outer Continental Shelf crude oil for in situ burning and to determine the likelihood of their residue sinking after burning.

Consequences to Operations based on Uncertainty of Research Information

Because of uncertainties in extrapolating laboratory results to actual spill conditions, responders cannot confidently predict the amount of residue and if/how much of the residue from burning of heavy crude oils and refined products will float or sink.

Surface recovery of residues that may sink has a very short window of opportunity, but could be effective since residues are readily recovered manually or with sorbents. Limitations include logistics, worker safety, and delay in ISB operations. Residues can be re-burned, further reducing waste disposal problems. However, once the residue sinks, recovery options are few, logistics-intensive, and ineffective.

Needed Research

1.) Field trials and study of actual spills where ISB is conducted are needed to determine whether or not the small-scale test data and predictive models developed to date apply to large burns. Results from these tests would be used to refine models that predict residue behavior.

2). Chronic toxicity tests using burn residues, benthic organisms and habitats, and realistic exposure levels and pathways are also needed to verify limited toxicity studies.

References

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