INTERNATIONAL

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Standard Guide for In-situ Burning of Oil Spills on Water: Ice Conditions[1]

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1. Scope

1.1 This guide addresses in-situ burning as a response tool for oil spills occurring on waters with ice present.

1.2 There are several methods of control or cleanup of spilled oil. In-situ burning, mechanical recovery, dispersant application or natural recovery are the usual options available.

1.3 The purpose of this guide is to provide the user with general information on in-situ burning in ice conditions as a means of controlling and removing spilled oil. It is intended as a reference to plan an in-situ burn of spilled oil.

1.4 This guide outlines procedures and describes some equipment that can be used to accomplish an in-situ burn in ice conditions. The guide includes a description of typical ice situations where in-situ burning of oil has been found to be effective.

1.5 In making in-situ burn decisions, appropriate government authorities should be consulted as required by law.

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1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.* Specific precautionary information is given in Section 8. Guide F 1788 addresses operational considerations.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

F 1788 ~~Guide for Burning of Oil Spills on Water: Environmental and Operational Consideration~~ Guide for In-Situ Burning of Oil Spills on Water: Environmental and Operational Considerations

F 1990 Guide for In-Situ Burning of Spilled Oil: Ignition Devices

F 2152 Guide for In-Situ Burning of Spilled Oil: Fire-Resistant Boom

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *brash ice*—floating ice fragments less than 2 m across.

3.1.2 *close pack ice*~~—pack ice with concentration of 7/10 to 8/10.~~ —pack ice with concentration of 7/10 to 8/10 (fraction of a whole).

3.1.3 *fast ice*—ice attached to the shoreline.

3.1.4 *fire-resistant boom (FR)*—boom designed to contain burning oil.

3.1.5 *fracture or lead*—any break or rupture through very close pack ice, compact pack ice, fast ice, or a single floe.

3.1.6 *frazil or grease ice*~~—ice crystals forming on surface of water.~~ —ice crystals forming on surface of water, ice, or melt pools.

3.1.7 *fresh oil*—oil recently spilled, remaining un-weathered and un-emulsified.

3.1.8 *ice coverage*—a combination of ice pans, ice chunks, bergy bits covering 10 % to near 100 % coverage of water surface, more accurately described using other terms in this section such as *close pack ice*, *open water* , and so forth.

3.1.9 *in-situ-burning*—burning of oil directly on the water surface.

3.1.10 *melt pools*—accumulations of melt water on the surface of ice during thawing.

3.1.11 *open drift ice*—ice concentration of 4/10 to 6/10.

3.1.12 *open water*—less than 1/10 ice concentration.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.13 *residue*—the material, excluding airborne emissions, remaining after the oil stops burning.
3.1.14 *rotten ice*—sea ice that has become honeycombed and is disintegrating.
3.1.15 *very close pack ice*—pack ice with concentration of 9/10 to 10/10.
3.1.16 *very open drift ice*—ice concentration of 1/10 to 3/10.

4. Significance and Use

4.1 This guide is meant to aid local and regional spill response teams during spill response planning and spill events.

5. General Considerations for Making In-situ Burn Decisions

5.1 For marine spills of oil in ice conditions, in-situ burning should be given equal consideration with other spill countermeasures and may be the best available technology for ice conditions. In some cases, in-situ burning may be the only practical option.

5.2 The decision of whether or not to use in-situ burning in a given spill situation is always one involving trade-offs, that is, smoke plume and burn residue compared to oil left alone.

5.3 One of the limitations of recovery techniques for floating oil is effective containment of the slick. In-situ burning is subject to this constraint as a minimum thickness of about 2 mm is required for ignition and sustained burning of the slick. Natural containment of spilled oil can occur in some ice conditions. The presence of ice can inhibit the spreading and weathering of the oil slick. At higher ice concentrations, oil will spread more slowly than it would in open water. When ice concentrations are lower, spreading can still be reduced by the effect of wind herding. Oil herded by wind can concentrate against ice floes and can accumulate to thicknesses capable of supporting combustion.

5.4 In this guide, environments suitable for in-situ burning will be discussed. The matrix in Table 1 is provided to assist users of this guide.

5.5 Burning in an ice environment may be conducted remotely, lessening safety concerns.

6. Marine Environments

6.1 For the purpose of this guide, in-situ burning in ice conditions refers to marine and coastal waters, rivers, and lakes where oil spills may occur in ice-infested waters.

7. Background

7.1 In-situ burning protects the marine environment from the effects of an oil spill by consuming the oil by fire leaving as little as 1 to 10 % oil residue on the surface of the water. By removing the oil from the water and ice, the impacts on the surface and sub-surface biota are reduced. ~~Oil~~ Unburned oil released by melting ice may ultimately impact shorelines, including critical habitats such as marshes and bird rookeries. Oil floating on the surface has the potential to contact sea birds and marine life. ~~Stranding of~~ Stranded oil ~~in these environments~~ may result in adverse ~~impacts from contact with oil. Fresh oil burns most efficiently.~~ environmental impacts. The amount of oil spilled, the degree of ice cover, and weather conditions are factors that determine the impact of a spill and the burnability of the oil.

7.2 In-situ burning of an oil spill requires an ignition source with the ability to provide multiple ignitions (see Guide F 1990). The helicopter sling-mounted drum filled with gelled gasoline or diesel developed for lighting backfires during forest fire ~~fighting,~~ fighting is an effective system for igniting oil in ice conditions. Individual igniters dropped from aircraft may be used to

TABLE 1

Type of Waters	Status of Oil	Burnability
Marine Coastal Waters		
Open water (0/10 to 1/10)	Contained fire-resistant(FR) boom	Burn oil in boom
Very open drift ice (1/10 to 3/10)	Possibly contained by FR boom	Burn oil in boom
Open drift ice (4/10 to 6/10)	Herded by wind or contained by ice	Burn oil where sufficient thickness
Close pack ice (7/10 to 8/10)	Contained by ice leads or floes	Burn oil in leads and between floes
Very close pack ice (9/10 to 10/10)	Contained in leads and fractures	Burn oil in leads and fractures
Fast ice	Contained on surface of ice	Burn oil where sufficient thickness
Melt pools	Oil contained on melt pools or on surface through brine channels	Burn oil where sufficient thickness
Rivers		
Open water	Deflect and contain oil in FR boom	Burn oil in boom
Brash, moving ice conditions	Look for areas of oil pooled by wind, current or ice	Burn where sufficient thickness
Solid ice, oil under ice	Slot ice, deflect oil to surface to burn	Burn oil where pooled on surface
Solid ice, oil on top of ice	Dam oil on top of ice to contain and pool	Burn oil where pooled on surface
Lakes		
Open water	Contain in FR boom	Burn oil in boom
~~Brash ice conditions~~	~~Look for areas of oil pooled by wind, current or ice~~	~~Burn oil where sufficient thickness~~
Brash ice conditions	Look for areas of oil pooled by wind, current, or ice	Burn oil where sufficient thickness
Solid ice, oil under ice	Drill or slot ice to bring oil to surface	Burn pools of oil on surface
Solid ice, oil on top of ice	Dam oil on top of ice to contain and pool	Burn oil where pooled on surface

ignite oil contained by ice. Since burning is most efficient when the oil is relatively fresh and un-emulsified, sources of ignition should be identified by response planners in their pre-spill contingency planning.

7.3 In more open waters, containment by special fire-resistant booms may be required (Guide F 2152).

8. Recommendations

8.1 Use of helicopter-mounted ignition systems or individual igniters is a hazardous operation and all applicable safety instructions for their use should be followed. Hazardous materials may have to be handled as part of the ignition equipment. Appropriate MSDS sheets should be available and followed during use of this equipment.

8.2 The in-situ burning of spilled oil can be accomplished under ~~certain conditions:~~

~~8.2.1When~~favorable conditions when oil is ~~e~~:

8.2.1 Contained in close pack ice conditions (pack ice of 7/10 coverage or greater).

~~8.2.2When oil contained~~ 8.2.2 Contained in drift ice conditions is sufficient thickness to sustain a burn (drift ice of 2/10 to 6/10).

~~8.2.3When oil is contained~~ 8.2.3 Contained in fire-resistant boom (generally open water up to 1/10 ice coverage).

~~8.2.4When oil is trapped~~ 8.2.4 Trapped along an ice floe or herded by wind and has sufficient thickness to support a burn.

~~8.2.5When oil is contained~~ 8.2.5 Contained in melt pools on top of ice sheets.

~~8.2.6When oil is contained~~ 8.2.6 Contained in open fractures or leads in ice.

~~8.2.7When oil is flowing~~ 8.2.7 Flowing under ice in a stream and ice can be slotted to bring oil to surface to burn.

~~8.2.8When oil is spilled~~8.2.8 Spilled on surface of ice and has sufficient thickness to support a burn.

8.3 In-situ burning of oil may require certain regulatory approvals.

8.4 Although in-situ burns are efficient, there always will remain some residue and provisions for the recovery of that residue should be included in in-situ burn response planning.

9. Keywords

9.1 ice conditions; in-situ burning; oil spills

APPENDIXES

(Nonmandatory Information)

~~X1.HISTORICAL BURNS AND SPILL STUDIES (1)~~ X1. BACKGROUND INFORMATION ON ARCTIC IN-SITU BURNING

X1.1 ~~See Table X1.1.~~

~~X2.BACKGROUND INFORMATION ON ARCTIC IN-SITU BURNING~~

~~X2.1~~ Several field experiments have been conducted in the Arctic waters ~~off Norway~~ to determine the feasibility of burning oil in ice-infested waters. One experiment involved the release of 30 tons of fresh crude oil. It was observed that the oil weathered more slowly and to a lesser extent in ice than it would have in open water **(~~2~~1)**[3]. After approximately 10 days, samples of the oil showed that it had lost 20 % of its volume due to evaporation and that it had formed a 20 % water-in-oil mixture. These results indicated that oil spilled in such ice conditions could feasibly be treated using in-situ burning techniques. Burning was in fact evaluated as the best response method available for this particular spill situation **(~~3~~1)**. Another recent study evaluating different response methods for several possible spill scenarios for the ~~Barents Sea~~ Arctic concluded that in-situ burning would likely be the most effective option under certain circumstances **(~~4~~2)**.

~~X2.2~~X1.2 Other field experiments have been carried out to determine the effect of wind or lack of wind on the flame spreading from one slick area to another slick area, either directly connected to or physically separated from the burn area. Ambient temperatures for these experiments were typical winter range of -20 to +5°C. Wind speeds ranged from 5 to 15 m/s with some occasional calm periods. The small basins of oil (0.5 by 1.5 m) designed to simulate ~~broken~~an ice pack were separated from the main burn basin (15 m dia.) by 1.5 to 3.5 ~~m, a~~m. A 10 mm layer of crude oil, at different degrees of weathering, was placed in these basins. During relatively calm conditions, there was no spreading of flames from the main burn. When the wind was blowing from 2 to 11 m/s there was enough flame tilt (30 to 35 angle from horizontal) to ignite oil with 25 % of the light ends evaporated and a water-in-oil mixture containing 50 % water in the small basins 1.5 to 3.5 m from main burn. Efficiencies of these burns were measured at over 95 % **(~~3~~1)** . Even uncontained crude oil slicks which were burning at release continued to burn at nearly 90 % efficiency until slick thickness thinned to less than 1 mm **~~(5~~(3)**.

~~X2.3 Experiments have been conducted on Alaskan crude oils to determine burnability when fresh, weathered and emulsified with and without emulsion breakers. Wave tank tests by S.L. Ross have given general parameters for efficient burning of Alaskan~~

[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.