# UNIQUE DISPOSAL TECHNIQUES FOR ARCTIC OIL SPILL RESPONSE

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**ABSTRACT:** *Disposing of oil and oiled debris from Arctic oil spills presents problems not encountered in temperate regions. The remoteness of potential spill sites, the wide range of environmental conditions, the lack of support facilities like roads and dump sites, and the presence of permafrost make it impossible to use many standard disposal techniques used in the south. To solve this problem, Dome Petroleum Limited, has developed a number of unique techniques for disposing of oil and oiled debris in Arctic spill responses. These techniques include (1) a method for using air-deployable igniters to burn pooled oil, (2) an air-transportable burner that can be flown to remote sites to burn recovered liquid oil with water contents up to 80 percent, (3) a helicopter-transportable incinerator for burning oil-contaminated debris at remote sites, in which forced air cooling replaces refractory material as fire box protection, and (4) a fireproof boom, for offshore open water, that can collect and burn oil in one step. All of these techniques were developed to address specific disposal problems in the Arctic. They now form part of the industry's Beaufort Sea oil spill response arsenal.*

Over the past nine years, Dome Petroleum Limited has been one of several companies exploring for oil in the Canadian Beaufort Sea (Figure 1). In conjunction with these exploration activities, the company has an aggressive research program to develop techniques and equipment for oil spill response. The program has produced a considerable arsenal of response equipment that has significantly improved industry's capability for spill response in the Arctic. One of the areas that has received a great deal of attention is the development of strategies and equipment for disposing of recovered oil and oiled debris.

In more southern latitudes, the disposal options range from reprocessing recovered oil to direct disposal, by burial, of highly weathered oil (e.g., tar balls) and contaminated debris. The selection of an appropriate disposal option depends on the amount and type of oil and debris, the location of the spill, environment and legal considerations, and the likely costs.[6] Thorough contingency planning prior to a spill allows preselection of an appropriate method, so that during a spill details of potential disposal options are available to the response team quickly.

However, many of the disposal options available to southern response crews are unavailable in the Arctic. Potential spill sites are remote. Because of permafrost, ice-covered water for significant periods of the year, and the lack of support facilities such as dump sites, roads, and incinerators make many disposal techniques used routinely in the south of no use in the north. Permafrost, for example, makes the standard southern practice of burial infeasible for most arctic spills because disturbance of the permafrost layer at a disposal site may be a more important environmental problem than the disposal of the oil. In addition, the long distances unconnected by roads or other standard transportation systems make disposal at the response site the most attractive option.

To meet these special requirements for disposal of recovered spill material in the Arctic, Dome/Canmar developed specific disposal techniques and hardware, generally conforming to the following criteria:

1. Air-portability by helicopter
2. Ease of assembly and operation
3. Reliability of operation
4. Simple construction
5. Durability

The following sections describe four techniques and associated apparatus developed by Dome to meet arctic disposal requirements, based on these criteria. Each section describes the specific disposal problem addressed, the research undertaken to resolve the problem, and the resulting technique and equipment. Examples of how the resulting equipment has been used for spill response and in other applications are also provided.

## In-situ burning as a disposal technique

There is a small but finite probability offshore exploration and development activities may result in a blowout, releasing oil and gas into the marine environment. If such an incident were to occur near the end of the open water season in the Arctic, oil could continue to be released under the winter ice cover until the well flow was stopped (by natural bridging or relief well drilling). Conventional cleanup and disposal techniques would generally not be very useful under these circumstances. It was therefore necessary to investigate alternative means of dealing with oil released under a solid ice cover.

To do this, Dome conducted an Oil and Gas Under Sea Ice Project, to simulate an oil and gas blowout under first year ice. This experiment sought to improve the understanding of how oil and has behaved when discharged under sea ice and to assess the usefulness of in-situ burning as a disposal technique.

The experiment, conducted in 1980, involved the release of oil (Prudhoe Bay Crude supplied by the Atlantic Richfield Co.) and compressed air to simulate natural gas. In all, about 6 $m^3$ of oil and 1,000 $m^3$ of compressed air were released at two test sites in the Beaufort Sea. The oil and "gas" were released in a manner typical of a "standard" Beaufort Sea blowout (approximately 398 $m^3$/day) at a gas to oil ratio (GOR) of 140 $m^3$/m. Within 48 hours of the release, all of the oil and gas released under the surface of the ice had become encapsulated by a 1 cm layer of new ice. It remained trapped in this manner until breakup of the ice cover the following spring.

In early June of 1980, oil pools started to appear on the surface of the ice. This was the result of both ablation (ice above the entrapped

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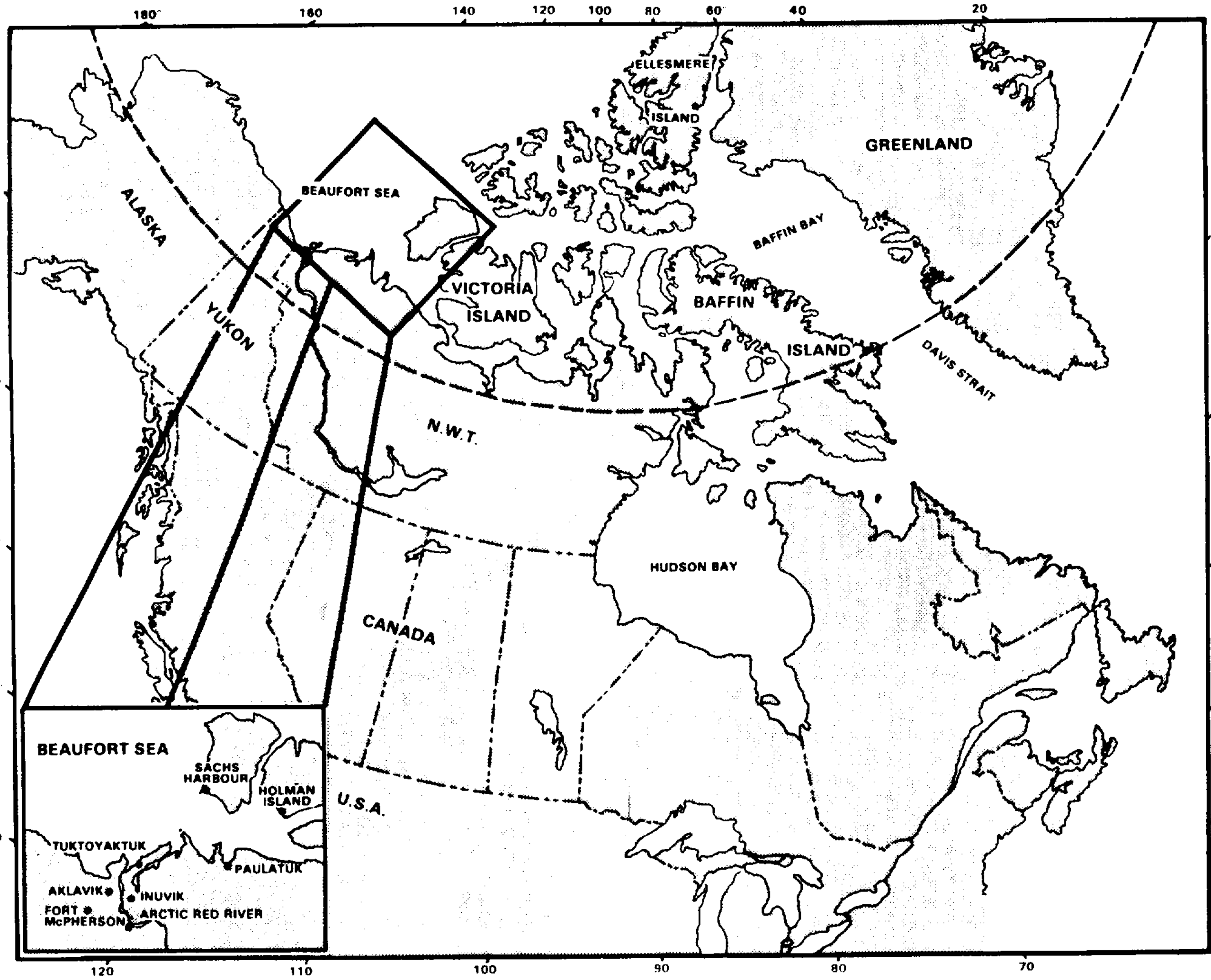


Figure 1. Map of Canada, showing southern Beaufort Sea

oil melting down to expose oil) and migration (movement of the trapped oil through ice brine channels). Once most of the oil had pooled on the surface of the ice, the pools were ignited using air-deployable ignitors.[3] These ignitors were specifically designed to be dropped from helicopters onto crude oil melt pools to initiate combustion (Figure 2).

Using these devices, approximately 30 percent of the oil pooled on the surface of the ice was disposed of by burning. With 30 percent lost through evaporation and 18 percent cleaned up manually, this left approximately 22 percent of the original oil volume discharged under the ice to disperse naturally into the water column during breakup.

This work has resulted in the development of a useful technique for disposing of oil released under land-fast sea ice. Dome and other operators now stockpile air-deployable ignitors for use in the event of an under-ice blowout. This technique has been incorporated into the company's Beaufort Sea Contingency Plan as a prime method for disposing of oil released at sea during the winter.

## Air-portable burner

One of the problems encountered during any major spill is the disposal of recovered liquid oil. Depending on the characteristics of the oil originally spilled, the recovered fluid can range from light fuel oil to heavily weathered residual oil ranging in viscosity from one to several thousand centipoise and containing large volumes of water (emulsion).[1] Although a number of burners were available for burning oil itself, they did not generally burn mixtures of oil and water efficiently. Furthermore, equipment such as flare burners using compressed air are generally heavy and require large support facilities. These features made existing burners generally unsuitable for use in remote Arctic areas.

Because of these shortcomings, the need was identified for a specialized helicopter-portable burner that could be used at remote spill sites. The following design criteria were established:[1]

- Portability by medium-lift helicopter (e.g., Bell 212; Sikorsky S-76)
- Durability
- Minimum of support equipment
- Simplicity of operation
- Ability to burn up to three metric tons of recovered fluid per hour
- High combustion efficiency
- Ability to atomize and burn fluid oil with viscosities of 400 mPa and emulsion contents up to 60 percent by volume
- Ability to deal with suspended solids in the fluid

Based on these criteria a system was designed and constructed through H. Saacke of Bremen West Germany. The initial prototypes were tested and modifications were made resulting in a final design with the following features:

- Burner weight, 1,264 kg

- Weight of the central unit, 900 kg
- 20 kW power source required
- Nominal burning capacity, 40 $m^3$/day with a maximum smokeless burn at 80 $m^3$/day at a water-in-oil emulsion of 60 percent
- Burner head can be swiveled through 360° to maximize air intake
- Self-checking propane ignitor and automatic ignition and shutoff equipment.

Comparison of these features with the original design criteria shows that the burner meets or exceeds all original requirements. During a three month test period in the Arctic the burner was used to dispose of over 1 million L of waste oil generated by Dome's northern operations, and over the last three years, this unit has been used successfully to dispose of all the waste oil accumulated during Dome's operating season (Figure 3).

Three of these units (one full-size and two half-size versions) are available as part of the industry's arctic spill response capability. Each can be flown to remote spill sites on short notice and can be used to dispose of oil recovered during spill response operations.

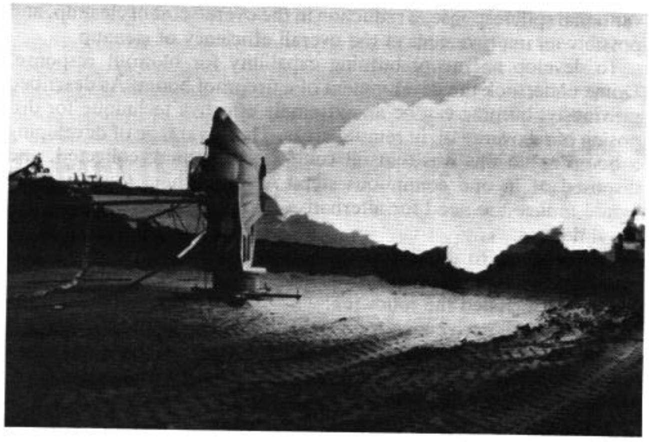

Figure 3. Saake burner being used to dispose of waste oil collected at Dome Petroleum's base camp, Tuktoyaktuk, N.W.T.

## Air-portable incinerator

In addition to the requirement for a means of disposing of recovered liquid oil, a technique was also needed for disposing of oil-soaked debris in an environmentally acceptable manner. Burning was again viewed as the preferred method for disposing of oily debris at remote sites because of the reduced need for transport, handling, and disposal. For effectiveness, several key features were included in the design criteria of the incinerator. Lightweight construction was specified so that the incinerator would be air-portable. A simple and reliable design requiring no precise alignment was also a necessity. Finally, the incinerator was to be capable of burning up to 1 metric ton per hour of weathered oily waste, under a wide range of loading conditions.

With these criteria in mind, a novel incinerator design was pursued through small-scale laboratory testing, construction of a full-scale prototype, and field testing of the full-scale unit.[8] The final design consisted of two air-portable units: a double walled, stainless steel incineration chamber and a diesel-driven blower (Figure 4). The unique operational feature of the incinerator is its use of blower-supplied combustion air not only to promote the burn but also to cool the firebox. This was achieved by circulating the air between the double walls of the incinerator prior to its entering the burning chamber. This feature eliminated the need for a refractory lining of the firebox, significantly reducing the weight of the unit. This feature also ensured that extended use would not damage the permafrost.

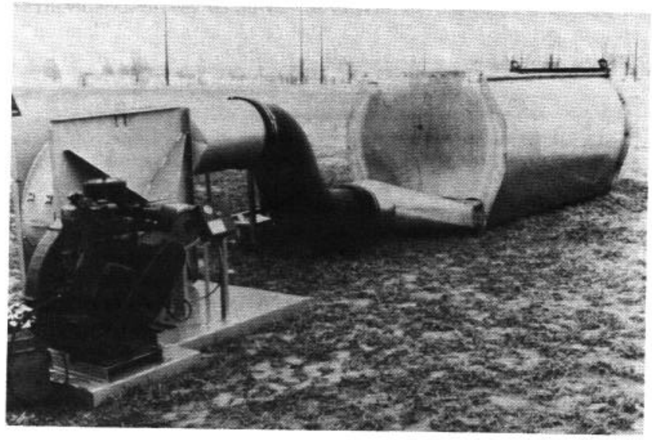

Figure 4. Air-portable incinerator

Figure 2. Burning crude oil poured on the surface of land-fast ice. Ignition was achieved by using an air-deployable ignitor.

The incinerator underwent two field tests, one at Waterloo, Ontario, in late 1982[8] and a second at Dome's base at Tuktoyaktuk, N.W.T., during September 1983.[9] The tests successfully demonstrated the utility of the unit. It was easily transported in two loads of 850 kg each. Field assembly took less than half an hour, using conventional hand tools. The unit was simple to operate and maximum loading rates of about 0.9 metric tons per hour were attained. The amount of smoke emitted during both tests was minimal.

Dome's incinerator is stationed in the Beaufort Sea, and commercially available units have been purchased by the Canadian Coast Guard and other oil companies for use in oil spill response. The unit has, in fact, been used to dispose of oil-soaked snow recovered as part of a land-based arctic spill response in early 1984.[7]

## Fireproof boom

During the Ixtoc 1 blowout in 1979, it was realized that if one could contain and thicken the released oil sufficiently, it would be possible to dispose of it by in-situ burning. The advantages of doing this include a significant reduction in logistic costs compared to a conventional spill response, a reduction in the overall cost of cleanup, and possibly an improvement in the overall efficiency of cleanup.

To develop an in-situ burning capability for blowout response, Dome undertook the development of a fireproof boom. As described previously, burning can be an extremely effective technique for disposing of recovered oil in remote areas. The advantage of developing a boom to do this was that oil could be contained, collected, and disposed of in one continuous step. Accomplishing this objective would reduce the need for alternative booming, collection, and disposal devices.

The program to develop such a boom started in 1979, took four years, and cost over $500,000. The design criteria for development of this boom included the following:

- Ability to survive long-term exposure to heat generated by burning crude oil (980° C)
- Ability to contain and burn oil in sea states of 2–3 on the Beaufort scale and at current speeds up to 0.4 m/s
- Ability to survive for long periods of time at sea
- Ability to withstand contact with small ice features

The final product was a stainless steel boom fulfilling all the above criteria. To reach this state of development, the boom underwent a number of trials under both simulated (Figure 5) and actual offshore conditions.[4,5] The details of the development and testing program have been reported previously.[2]

In an actual response to an offshore blowout, a conventional containment boom would be anchored or held by supply vessels to direct oil toward a "pocket" of fireproof boom. As oil moved into the pocket, it would thicken until it reached a thickness suitable for burning. The contained oil would then be ignited, and the fire would be maintained by new oil moving into the pocket. Although the boom is necessarily massive and heavy, it offers a significant advantage over conventional cleanup systems in that it can collect and eliminate large amounts of oil from an offshore blowout in one self-sustaining step, with a minimum of logistic support.

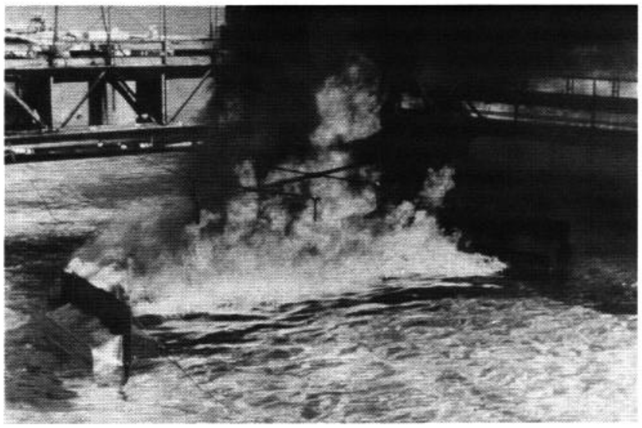

Figure 5. Fireproof boom being tested at the OHMSETT facility

The boom is presently part of industry's Beaufort Sea oil spill response equipment. It is also commercially available.

## Summary

A number of novel techniques have been developed for waste oil disposal in the Arctic. These techniques are presently available in the Beaufort Sea for response to oil spills. As a result of the development of these devices, disposal capabilities have been enhanced to the point where they are now better in the Beaufort Sea than in some other frontier areas. These devices could reduce the negative impacts of improper disposal techniques not only in the Beaufort Sea but in other parts of the world as well.

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