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**NRT FACT SHEET**

Prepared by the NRT Science & Technology Committee

# IGNITERS AND IGNITION TECHNOLOGY FOR *IN SITU* BURNING OF OIL

## SUMMARY

The process of igniting an oil slick is critical to the success of any *in situ* burn event. Often, the window of opportunity for a burn may be only a few hours, limited by emulsification and weathering of the oil slick. Igniter systems need to be safe, effective, convenient to use and store, and ready for use directly out of storage. Most ignition devices of the past failed one or more of these criteria and are no longer used. Current systems are effective in most conditions: improvements, however, are still needed. Future research and development efforts need to focus on ignition of emulsified and weathered oils; on combating the effects of wave action on the ignition process; and on improving the safety, reliability, and availability of small hand-held ignition devices.

## BACKGROUND: OIL SLICK IGNITION

To ignite oil on water, an igniter must deliver enough heat to volatilize the hydrocarbons in the oil fast enough to maintain the vapor concentration necessary to support burning. Additional heat energy must then be provided to actually start burning the oil. The flash point of an oil is the temperature at which the rate of hydrocarbon vaporization is sufficient to catch fire. The ambient temperature of a slick and its flash point are important considerations for ignitability and safety issues. If an oil is at a temperature below its flash point, the igniter must provide the energy to heat the oil above its flash point. For an oil slick on water, conduction and convection in the slick can quickly dissipate heat energy. Thus, for successful ignition, a slick must be thick enough to minimize heat dissipation and allow the surface layer near the igniter to heat above its flash point. The thickness necessary for ignition depends upon the type of oil and its degree of weathering: fresh, volatile crude requires a minimum thickness of 1 millimeter (mm), whereas aged, non-emulsified crude and diesel fuels require 3 to 5 mm (Buist, *et al*., 1994). Other factors affecting the ignitability of oil slicks at sea include wind speed; igniter strength, heat flux, and flame duration; ambient air, oil, and water temperatures; wave action; and degree of emulsification of the oil slick (Buist, *et al*., 1994).

In the design of an ignition system, the rate of energy release must be balanced between two extremes. The igniter must provide enough heat energy for the vaporization and ignition of a slick. An abrupt, explosive release of energy, however, can blast the oil away from the igniter, decreasing the likelihood of ignition. Other considerations for design include safety in operation, storage, and transportation; simplicity of design and use; durability to survive free-falls (for aerial systems) from altitudes of at least 50 to 100 feet (15 to 30 meters); and reliability after long-term storage.

## PAST IGNITER TECHNOLOGY

Development of igniter technology began with the first major *in situ* burn event, the *Torrey Canyon* spill in 1967. Since then, many ignition devices have been developed and are no longer used, primarily because of concerns about safety in storage, transportation, and operation.  Major highlights in igniter development, as listed by Buist, *et al*., are as follows:

- ***Kontax:*** Marketed by a German manufacturer in the early 1970's, the Kontax igniter used metallic sodium and calcium carbide as flame sources.  It was taken out of production after only a few years, probably due to lack of interest in *in situ* burning at the time.

- ***Solid propellents (solid rocket fuels):*** Several devices developed in the 1970's used solid mixtures of ammonium perchlorate and metal fuels (such as magnesium or aluminum), producing very high flame temperatures (2280°F/1250°C).  They are no longer recommended because of safety considerations and questionable reliability after lengthy storage.

- ***Solid fuel:*** These igniters used kerosene cubes to produce flame temperatures of 1400°F/770°C. Despite a high success rate of 80-85%, they are no longer recommended because of safety considerations and questionable reliability after lengthy storage.

- ***Thermite:*** These devices used a mix of metallic aluminum powder and ferric oxide to produce extremely high temperatures (6300°F/3500°C): however, a high temperature (3600°F/2000°C) was required to start the reaction.  These are no longer recommended because of restrictive storage and transportation requirements.

- ***Marker flares:*** Various road and marine flares composed of phosphorous, calcium hydroxide, or magnesium have some success igniting oil that is already above its flash point.  They are ineffective, however, on slicks at sub-flash temperatures.

- ***Hypergols:*** Hypergol devices consist of two separately-stored liquids, a strong oxidant and a combustible, which burn rapidly upon mixing.  They are not recommended due to dangers in storage and handling.

- ***Sodium and gasoline igniters:*** These igniters use metallic sodium, which ignites upon contact with water, to ignite a container of gasoline.  The success rate is low because the sodium can become coated with oil or gasoline, sealing it from water.  Also, storage and handling dangers exist.

- ***Premo Aerial Ignition Device:*** Intended as an aerial ignition system, this device mixes glycol and potassium permanganate inside polystyrene balls: an exothermic reaction ensues, and the balls are ejected into the slick.  Although successful under some conditions, this device often fails because the polystyrene balls are easily doused and sunk.

- ***Laser ignition systems:*** In the late 1980's, Environment Canada sponsored laboratory and field tests on a dual-laser ignition system.  A continuous-wave carbon dioxide laser was used to heat a localized area of an oil slick above its flash point: then, a high-powered pulse from a second laser was focused at the vapors directly above the oil, igniting them.  Although tests under controlled static conditions were successful, feasibility studies for a helicopter-mounted system showed potential difficulties in laser beam focusing and aiming.  Further development has not proceeded because of cost and the success of conventional pyrotechnic devices.

- ***Pyroid igniter:*** Developed by Canadian Environmental Protection Service, the Pyroid igniter is a 4- lb (2 kg) hand-thrown unit, composed of ammonium perchlorate and metal fuel (aluminum or magnesium) sandwiched between two layers of foam floatation. The device cannot be activated until the safety pin is pulled: thus, it is safer to handle and use than previous igniters of similar design. The igniter produces a high-temperature (4200°F/2000°C) flame for a duration of 2 minutes. It has exhibited a success rate of at least 75% in aerial deployment operations; however, its reliability drops after 5 years of storage. No Pyroid devices have been built for commercially sale, but design schematics are available through Environment Canada.

**CURRENT IGNITER TECHNOLOGY**

- Surface or vessel-deployed igniters are often simple: butane torches can be effective, as can rags or sorbent pads soaked in diesel and sprayed with dimethyl ether. Gelled gasoline in a plastic bag was used at the *Exxon Valdez* spill: the bag was placed on the water, ignited, and allowed to drift from the towing vessel into the oil contained in a fireboom behind the vessel. These ignition methods are not altogether safe, however, because they place personnel with open flame near the flammable vapors emitting from a slick. To minimize the hazards of the ignition process, devices have been developed for aerial ignition of slicks:

- ***Dome igniter:*** Developed by Dome Petroleum, Ltd., of Calgary, Canada, this 1 lb (0.4 kg) hand-thrown unit consists of a fuel basket filled with solid propellent and gelled kerosene slabs suspended between two metal floats. Producing a 10-minute flame of moderate temperatures (1400¿F/800¿C), the igniter has a high rate of success (around 90%), and is capable of igniting various weathered and emulsified oils in low temperatures and high winds. The igniter requires an open flame to start its fuse, however, and has special shipping and storage requirements under federal regulations. The device is currently available through Energetex Engineering of Ontario, Canada.

- ***Helitorch:*** The igniter used most often is the Helitorch, a self-contained unit consisting of a fuel barrel, positive-displacement pump, and motor assembly. Weighing 534 lbs (243 kg) with a 55 gallon drum of fuel, the unit is carried beneath a helicopter with a support cable, and is controlled with electrical connections. The fuel barrel is filled with gelled gasoline or a gasoline/diesel mix, which is pumped on demand through a nozzle and ignited with propane jets. The falling stream of burning fuel separates into individual globules, and flattens upon impact into discs 5-7 inches (13-18cm) in diameter that burn for 4 to 6 minutes. Its success rate is high, and it has successfully ignited crude oil in winds up to 16 knots (30 km/hr). The Helitorch is usually applicable only in large-scale spills, however, because of the complexity it adds to response operations. The device is currently manufactured by Simplex Manufacturing Co. of Portland, Oregon.

**RECENT R&D EFFORTS**

Recent research has recently focused two issues: development of safer hand-held flare igniters, and ignition of emulsified and weathered oils.

- ***Navy SUPSALV flare igniters:*** The Helitorch is sufficient for the ignition of large-scale spills. Ignition of smaller spills, however, is often better accomplished by something more portable and convenient. US Navy SUPSALV has recently sponsored development of safe, low-cost, hand-deployed flare igniters. No more hazardous to ship and store than common road flares, the 1_ lb igniters use a mix of metal compounds (barium sulfate, strontium nitrate, potassium perchlorate, aluminum, barium nitrate, and manganese dioxide), ignited by time-delay electronics, to produce a very hot intense flame for 3 minutes. Initial prototypes in 1994 and early 1995 were unsuccessful because of unstable flotation attitude and large reaction forces from the flame. Redesign by SUPSALV resulted in a self-righting reusable flotation platform made of steel and heat-treated aluminum. Hand-deployed from either the surface or an aircraft, the platform holds the flare igniter at the proper flotation attitude during ignition. A section of oleophilic, hydrophobic wicking material 6 feet square is attached to the platform to enhance ignition. As it floats on the oil surface, the wicking material continuously supplies oil to the igniter flame; the flame spreads easily over the wicking material, creating a much larger burn area than that of the flare alone. The device successfully ignited diesel and crude oil in baseline tests. Future testing will include crude oil emulsion tests, wind tests, aerial drop tests, and cold oil or ice tests (Moffatt, 1995).

- ***Ignition of emulsified oils:*** The difficulty in igniting an oil slick is compounded by the onset of emulsification. Considerable research has recently been directed at studying the ignitability of emulsified oils. An emulsified oil requires separation into its oil and water components prior to ignition, forming a layer of oil on top: this top layer must then be heated to a temperature above its flash point, causing the vaporization required for ignition. Alaska Clean Seas, Norwegian Clean Seas Association for Operating Companies, and other organizations have tested two effective ways for breaking the emulsion: 1) providing a heat source hot enough and long enough in duration to boil away the water; 2) applying emulsion-breaking additives to the slick, either directly or within the igniter itself. The greater the water content of an emulsion, the hotter the igniter required to break the emulsion and ignite the oil. Alaska Clean Seas has shown that conventional gelled gasoline igniters can ignite emulsions of up to 25% water content. Application of emulsion-breaking additives to the slick increases the effectiveness of an igniter: used in conjunction with emulsion-breakers, hotter-burning gelled crude can ignite emulsions of up to 65% water content. However, the area of application of the emulsion breaker must be agitated for an hour or more before ignition of the slick.

## FUTURE R&D NEEDS

Although current igniter systems are effective in many situations, further research is needed. Little is known about how to counter the deleterious effects of wave action on the ignition and burning of oils and emulsions. Tests are planned within the next year by S.L. Ross Environmental, Ltd., and Alaska Clean Seas, to investigate protocol for igniting and burning oils under wave action (Buist, 1995). Other future R&D efforts should focus on the following areas:

- Continued development of hand-deployable surface or aerial ignition systems, focusing on increased safety of use and storage and increased shelf-life beyond the standard 5 years.

- Continued research on ignition of emulsified oils to develop a protocol, based upon emulsion water content or other parameters, for selecting the ignition method, fuel type, and emulsion-breaking method.

- Development of emulsion-breakers that require a short time (less than one hour) to act.

- Improvement of the Helitorch igniter with chemical emulsion-breakers or temperature promoters for increased effectiveness on emulsified slicks.

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