AN INCENDIARY DEVICE FOR THE IGNITION OF OIL IN MELT POOLS

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1.0 INTRODUCTION

An incendiary composition capable of igniting oil slicks on water must provide a sufficiently high heat flux, by way of a high-temperature flame (< 2000°C) spreading over a large area, for a relatively long period of time (>5 min). Although the adiabatic flame temperatures of most gaseous hudrocarbons lie in the range of 1800 to 2100°C, they are disqualified because this temperature drops substantially under actual burn conditions, mainly due to the presence of excess air. Propane, for example, can only be expected to burn at roughly 1100°C in the open Arctic environment. The same is true for liquid (e.g. gasoline) and solid (e.g. gelled kerosene) hydrocarbons, for which combustion under the expected environmental conditions would yield relatively low flame temperatures and heat outputs. Barbeque starter (gelled kerosene) has been reported to burn with a flame temperature of 771°C and with a low flame radiation of 0.5 kW/m^2.

A much hotter and more vigorous chemical reaction is,therefore, required. The defence Research Establishment Valcartier (DREV) has long experience with propellant and pyrotechnic compositions that, properly adapted, would appear capable of meeting the criteria for igniting oil slicks. Such a composition will be employed in the development of a helicopter-deployable incendiary device by DREV under terms of a Memorandum of Understanding, signed in December 1978, between Fisheries and Environment Canada and the Department of National Defence.

Environment Canada. Arctic and Marine Oilspill Program (AMOP) Technical Seminar, 2nd. Proceedings. March 7-9, 1979, Edmonton, Alberta, Canada, Environment Canada, Ottawa, Ontario, 232-238 pp, 1979.

2.0 INCENDIARY COMPOSITION

A composite propellant or pyrotechnic material is well suited for this role. They consist basically of a fuel, oxidizer and rubber binder, with other ingredients, such as a filler, added as required. Typically, the fuel could be aluminum, the oxidizer ammonium perchlorate and the binder either a polyurethane or a polybutadiene rubber; the latter is now in use at DREV.

The binder consists of a rubber-based polymer that serves to hold together all ingredients in a homogeneous solid of any desired form. The ingredients and the binder (in its liquid form) are thoroughly mixed together, then poured into molds and allowed to cure. The resulting material is robust with good mechanical properties. This type of composition has been demonstrated by Energetex Engineering to be capable of igniting oil slicks when held in a simple, but crude, type of flotation device (Energetex, 1978).

The main advantage of composite compositions is their high heat of reaction. The actual flame temperature is well in excess of $2000^{o}C$ and the heat per mass output is about twice the lower heat value for hydrocarbon fuels (or about 4 times the actual output of the latter). In addition, because the composition contains its own supply of oxygen, the reaction will be near stoichiometric and will not be readily susceptible to extinction by water, ice floes, wind, etc.

A filler, not normally part of a propellant on pyrotechnic composition, will be incorporated:

a. to regulate the burning rate of the composition; and
b. to reduce the density of the composition so that it will float on water.

The filler material will be in the form of hollow spheres or microballons, as they are known commercially. Several different types made of sodium borosilicate glass, ceramic, and phenolic compositions are being evaluated. Depending on their make-up, they have a true density ranging from 0.15 to 0.35 g/cm^3, and average diameters ranging from 50 to 100 μm. The filler must control the rate of burn without sacrificing performance (i.e. the filler must not serve as a heat sink to the com-

bustion process).

The concentration of filler will be adjusted to give the incendiary device an overall density of about 0.9 g/cm^3. This will eliminate the requirement for a cumbersome flotation system which, when functioning improperly, could prevent the correct operation of the device.

3.0 DESIGN OF INCENDIARY DEVICE

At this early stage in the development, a cylinder burning only at one end (cigarette burner) has been adopted for initial testing. The incendiary composition is cast into cardboard tubes (molds) to which it bonds upon curing. When ignition occurs at one end, the tube prevents burning from spreading in an uncontrolled way up the side of the cylinder. As a result, the burning surface is confined to one end of the device.

An additional container is not envisaged at this time. The strength and resistance to impact of the composite incendiary material, reinforced somewhat by the cardboard tube, should be more than sufficient to withstand the landing shock on water or ice following deployment from the air. This will keep the size and weight down and obviate further production steps.

A suitable igniter will be attached to one end of the tube containing the incendiary composition; it will be either chemical, electrical, or mechanical in nature. An appropriate mix in the former category is the exothermic reaction between potassium permanganate and ethylene glycol. An electrical igniter would involve a circuit either hand-triggered or triggered by an impact switch, while a mechanical device would employ either an impact percussion plunger or a spring-loaded hammer striking a firing cup.

The overall dimensions of the incendiary device are now envisaged as 5 to 10 cm in diameter by about 20 cm in length. It will contain from 1 to 2 kg of incendiary composition that will burn for 5 to 10 min with a flame temperature in excess of $2000^{\circ}C$. It will release some 25 million calories to the local environment.

4.0 SUMMARY

DREV has just started to develop an incendiary device for the ignition of oil in melt pools in the Arctic. The incendiary composition will be based on the years of experience DREV has had in dealing with composite propellant and pyrotechnic compositions. Preliminary testing has commenced, but no results are as yet available. All work is being directed towards a final design that will be light, cheap to mass produce, easy and quick to deploy and reliable in operation.

REFERENCES

Energetex Engineering. 1978. Testing of Air-Deployable Incendiary Devices for Igniting Oil on Water.

DISCUSSION

Comment:

Don't take the $5.00 or $10.00 cost as being the cost we may end up with. That is what we would like to end up with. There have been no cost studies done and again would depend on the length of the production run.

Q. I'm very interested in work that is being done and hope to follow up on it. The obvious concern of the user, more than how effective it will be and what it will cost, is how safe it will be and trying to get the helicopter operators to agree to put it in their aircraft. You mentioned the word once or twice but it was not the most frequently mentioned word in the discussion. I would like you to spend a few seconds talking about the safety considerations and what you think about storage considerations, shelf life considerations, that aspect.

A. All the items that we develop with the Canadian Forces have very, very stringent requirements in all of the aspects you just mentioned. All of the stringent requirements and more will be applied to the development of this device. It will be adequately cleared for dropping from helicopters. Depending on what we end up with with AMOP's requirement on the storage life and how we see this, the storage life of this material can be very long but you may have to add some sort of outer casing if you want it to last for 10 or 15 years. So again that will have to be the requirement of AMOP and so on. It would have to be worked out. The safety of this thing will be of the utmost importance as it is with all types of military devices. I think you can rest assured on that side that we will be going through exactly the same steps that we do for any military items.

Q. Two quick questions - what was the weight that you stated, the approximate weight?

A. Roughly one to two kilograms.

Q. Will that float?

A. Sure, depending on the size.

Q. How long do you think it will take to develop this and after it is developed how long do you think it will take to clear it so that the public will be able to purchase it?

A. To develop it in its very final form from 1 to 2 years. To clear it, I can't answer. If you are going to have a commercial application it has to go through the Dept. of Transport and you know how fast governments work. Of course, we are going to design it so that it will be cleared, it is not going to be something that is impossible to clear.