FIELD TEST OF WASTE OIL COMBUSTION AND EMPTY DRUM CLEANING AT ALEXANDRA FIORD, NWT

by

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ABSTRACT

A combined research and remediation project was carried out in August and September 1995 to test procedures and portable equipment for disposing of waste-petroleum at remote Arctic sites. The site for the work was Alexandra Fiord, a seldom-used RCMP base on Ellesmere Island, Northwest Territories. There, a crew of ten people safely and cleanly disposed of approximately 40,000 L of waste-fuel in five days, using two flare burners. The burners used were the SAACKE SKV-150 and the SWIRLFIRE Mk. I, both of which are owned by the Canadian Coast Guard. The drums that contained the fuel were cleaned with a high-temperature pressure washer and removed from the site.

1.0 INTRODUCTION

Hundreds of thousands of oil drums have been dumped or stockpiled in the Canadian Arctic in the past fifty years. The stockpile locations include DEW Line sites and other military installations, exploration and industrial sites, fuel depots for shipping and air transport, and municipal dumps. The drums are of varying ages (pre-WWII to the present) and contain various chemicals including waste fuels and lubricating oils, antifreeze chemicals, assorted solvents, and other waste materials.

Such wastes would normally be collected and transported to southern facilities for analysis and subsequent disposal, treatment or recycling; however, due to the large number of drums, their age and their scattered distribution this disposal method would not only be very expensive, but would also increase the possibility of spills during drum handling and shipping. Accordingly, it has been proposed that as many of the drums as possible be analyzed on-site for contaminants (such as heavy metals, PCBs and other chlorinated compounds), and, if established contaminant criteria are met, the drum contents should be destroyed using portable flare burners. The concept of a combined program of analysis and disposal is attractive from both logistical and environmental perspectives. The problem is that technologies are not proven for either the on-site analysis or the disposal of waste petroleum products at remote Arctic locations that are only accessible by ship or small aircraft.

The Canadian Coast Guard, Northern Region, spearheaded a major effort to deal with this environmental problem by organizing a test programme at the RCMP post of Alexandra Fiord. The objective of the project was to develop and test a portable system for safely and cleanly burning waste fuel and other petroleum products at remote Arctic sites, and subsequently decontaminating the empty fuel drums for recycling. During the
planning stages of the project another goal was set: to use the system to completely destroy all the waste fuel at Alexandra Fiord and transport all the empty fuel drums and other debris south for recycling or disposal.

The waste fuel at the site was tested for contaminants in the summer of 1994 (Meakin 1994). After the results were reviewed by environmental regulators in Yellowknife, it was decided that disposal by flaring was acceptable and sensible. The disposal plan involved the use of two existing flare burners, the SAACKE SKV-150 and the smaller SWIRLFIRE Mk. I, both of which are owned by the Canadian Coast Guard. The burners were designed in the early 1980s to be helicopter portable and were originally to be used to dispose of waste oil recovered from oil spill cleanups. The plan was to empty the waste fuel into two temporary containment tanks, from which it would be fed continuously to the burners. The emptied drums would be cleaned with a steam-generator or pressure washer.

1.1 Site Overview

The RCMP post is situated 750 km from the North Pole, on the eastern shore of Ellesmere Island, Northwest Territories. At this site there were 482 drums containing some 40,000 L of oil products (aviation fuels, diesel, kerosene, stove oil and lubricating oils) that required processing. Most of the drums were old and rusting, and many were already leaking. Figure 1 is a schematic representation of the Alexandra Fiord base showing the location of the landing beach, airstrip, major buildings and locations of the drum caches.

The 482 drums requiring disposal were situated in three locations: three drums were behind a small building on the periphery of the base, but contained only scrap metal and junk; the majority, consisting of 464 drums, were neatly stacked near the landing beach (hereafter referred to as the "large drum cache"); the remaining drums containing fuel (the "small drum cache") were located farther from the shoreline near the airstrip.

1.2 Planning and Scheduling

The trial could only be conducted between late August and mid-September, during the short period of time when the fiord and the sea route to the site were usually free of solid ice. Procedures and a list of equipment required to empty the fuel from the drums, move the fuel to the burners, and clean the drums were prepared in July. Heavy equipment (i.e., burners and fuel) and items that could not be transported by air were gathered and shipped to Dartmouth, Nova Scotia in July, where they were loaded onto the CCGS Louis St. Laurent for transport north. The CCGS Louis St. Laurent rendezvoused with the CCGS Sir John Franklin, the icebreaker assigned to support the demonstration project, in early August and transferred the equipment. The remainder of the equipment was shipped by air to Resolute Bay. It was loaded onto the CCGS Sir John Franklin prior to the arrival of the project team.

FIGURE 1: Schematic diagram of Alexandra Fiord RCMP base
The original dates scheduled for the demonstration project were from August 24 to September 13, 1995. The schedule, based on an estimate of the waste-fuel volume, allowed for two contingency days for bad weather. This limited safety margin was worrisome because, in the event of a protracted stretch of inclement weather, it would have been disappointing and expensive to have to return to Alexandra Fiord to complete the disposal. Also, because the ice encountered during the trip to Alexandra Fiord was heavier than usual, the captain of the icebreaker was concerned about becoming trapped in heavy ice during the project, and requested that the days on site be reduced to the fewest possible. It was therefore decided to accomplish the mission as quickly as possible.

2.0 EQUIPMENT PREPARATION AND SITE SETUP

The ship arrived at Alexandra Fiord in the evening on the 27th of August, and anchored approximately 700 m offshore. During the trip from Resolute Bay, as much of the
equipment as possible (pumps, generators, burners, pressure washers, hose and valve systems) had been unpacked and prepared for use.

One hour before arriving at Alexandra Fiord, three members of the project team flew to the site by helicopter to conduct a survey. Suitable areas for all major pieces of equipment (i.e., burners, generators, porta-tanks, pillow tanks) were located and marked. The quantity and condition of the drums at the large fuel cache remained unchanged from 1994; however, inspection of the small drum cache at the airfield revealed that some drums had been removed and others had been marked as being in use (mostly by the Polar Continental Shelf Project and the RCMP). Of the 66 drums that were identified the previous year (Meakin 1994), only fifteen remained that were not marked as being in use.

All of the equipment was transported by helicopter from the ship to the site on the evening of the 27th, except the SAACKE burner head and the drum-washer which were shipped over the following morning. The helicopter transported the smaller pieces of equipment to the site in cargo nets. The larger pieces (i.e., burners and SAACKE generator and control unit) were slung individually.

The MBB-105 helicopter assigned to the CCGS Sir John Franklin had a specified lift capacity of approximately 500 kg, but also carries approximately 450 kg of fuel when full, so actual lift capacity depended on the level in its fuel tanks. All of the equipment, except the SAACKE generator and burner head, was within the lift capacity of the helicopter. The generator had to be taken apart and rebuilt on shore. To reduce the weight of the burner head during transport, the heavy, heat-shielded power and fuel supply hoses were detached from the unit and reattached on site. Normally, neither the generator, nor the burner head, should be considered transportable by an MBB-105.

The following day, all of the equipment was unpacked, the tanks were assembled and situated properly, and the hoses were unravelled and connected. Setup of the site was accomplished in eight hours by ten people.

3.0 SITE CLEANUP

The day-to-day cleanup operations took place in three distinct areas: the drum emptying site; the drum cleaning site; and, the waste-fuel disposal site.

3.1 Drum Emptying

The drum emptying operation involved transferring waste oil (aviation gasoline, lubricating oil, kerosene, Iosol, diesel and stove oil) from drums into temporary storage tanks. Figure 2 is a schematic diagram of the drum emptying sites showing key pieces of equipment and their locations. The drums containing the waste oil were mainly 45 or 10 gal. drums, although there was some lubricating oil contained in 10 gal. pails, 1 qt. metal cans and 1 qt. plastic bottles. Most of the drums in the large cache were neatly stacked in rows, two drums high. The oil was emptied from each drum at the cache using an explosion-proof fuel pump and transferred to custom-built holding tanks.
The procedure followed to empty the drums was:

i) tip the drum upright onto the containment platform;

ii) ground the drum;

iii) remove both bungs;

iv) determine and record the fuel type and the height of fuel in the drum (for calculation of fuel volume);

v) pump the fuel to the pillow tanks;

vi) tip the empty drum over the nearby open-top residue drum (to empty any remaining oil - usually 1 to 2 L);

vii) remove the empty drum to the drum cleaning area; and,

viii) periodically pump the accumulated oil from the residue drum to the storage units, which were flexible "pillow" tanks.

FIGURE 2: Schematic diagram of drum emptying site
The procedure worked well; total time to empty a full 45 gal. drum of aviation gasoline (av-gas) was typically three to four minutes. A drum of diesel or kerosene required approximately the same time. Lubricating oil, being considerably more viscous, required longer. As much of the lube oil as possible was diluted with av-gas to lower its viscosity before pumping. This was accomplished by adding the lube oil to the open-top residue drum when it was mostly full with av-gas. Between 60 and 80 drums were emptied per day, in the first four days (187 drums at the large cache were already empty). The procedure operated most efficiently with four workers.

Two portable containment platforms were constructed from simple materials (tarpaulins, plywood and rope); the drums were tipped upright onto the stable platforms, which were lined with sorbent materials to contain any spilled oil. The platforms could be lifted by two persons so that, when a row of drums was completely emptied and removed to the cleaning area, the platforms could be moved to the next row of full drums.

To prevent sparks, non-sparking bung wrenches were used when opening the drums, and the check valve and nozzle used on the suction pipe from the fuel-transfer pump were made of bronze. Also, the drums were grounded to prevent static electricity discharges by connecting them with automotive booster cables to a piece of metal reinforcing-bar driven into the earth.

Originally, it was planned to measure the water content of each drum in order to monitor the amount of water pumped to the burners; however, samples taken at the beginning of the operation indicated that virtually none of the drums contained significant volumes of water. The extra time required to perform the test was not justified. Only the fuel type and the height of liquid in the drums were determined.

The suction end of the hose that was inserted into the drums was fitted with a 1.5 m section of PVC pipe to reach the bottom of the drums, a bronze check-valve (foot-valve) to prevent spilling oil when the hose was transferred between emptied and full drums, and a nylon-mesh filter to minimize the uptake of rust and other solid contaminants from the bottom of the corroded drums. There was a considerable amount of rust and debris in the majority of the drums, which tended to clog the filter and necessitated periodic cleaning (about once per two drums). The mesh size was too coarse to prevent the passage of all of the debris (mesh openings were approximately 1.5 x 1.5 mm). On the final day one of the pillow tanks was sliced open. There were brown and rusty granular solids of various sizes inside, which meant that some of the solids had passed through the filter and made their way into the tanks and possibly to the burners. A finer screen would have reduced the amount of rust being passed through the pump. Although this would have required more frequent cleaning, it would have provided better protection for the mission-critical burners.

The waste oil from the drums was pumped to the two pillow tanks. The tanks were connected to the pump through a valved tee, by which the oil could be directed to one tank or the other. The process involved filling one tank while allowing the other to feed the burners. This was necessary because, while it was possible to fill the same tank that was feeding the burners, air was fed into the line when the suction was switched from
a freshly emptied drum to a full drum. By alternating between the two tanks, enough time was allowed for any air to escape through the bleed/relief valve.

The pillow tanks specified in the project plan (S.L. Ross 1995) were not delivered in time, and replacements had to be quickly manufactured by the supplier. The replacements performed well, considering that the supplier had no prior experience at manufacturing pillow tanks; however, there were deficiencies:

i) the original tanks were supposed to be able to contain 2 m³ of liquid, whereas the ones supplied were limited to approximately 1.2 to 1.3 m³;

ii) the outlet valves were positioned too high on the tanks and prevented complete unassisted emptying; and,

iii) the material from which the tanks were made (oil-containment boom fabric) was susceptible to degradation by the waste fuels.

The consequence of the first and second deficiencies was that the pillow tanks had to be filled more frequently (approximately once every 1.5 hours), which was less efficient. With respect to the third deficiency, after two days of operation the tanks had become noticeably stiff and brittle. Although the tanks were handled carefully, a pinhole leak developed at a seam on one of the tanks on the fourth day of burning (Sept. 1). The leak was noticed almost immediately and very little fuel was spilled (the spill was contained by the tarpaulin and quickly soaked up by the sorbent socks around the tank). The tank was drained and replaced with the spare. Unfortunately, the spare tank also had a leak due to an unfused seam at one edge. The hole was small and was sealed by placing a "C"-clamp over the seam. The tanks held for the remainder of the project; however, the fabric had become brittle and the tanks could certainly not have been reused.

On the second day of operation (Aug. 31) the 15 fuel drums at the airstrip that had been identified as waste were moved to the drum emptying site, by helicopter. The same day, 29 of the 32 drums of arctic diesel in the large fuel cache, were transported to the ship and transferred to the fuel tanks for use in the ships engines. This "co-disposal" helped speed up the cleanup operation, saving approximately six hours of time, and was also an excellent opportunity to put left over fuel to good use. It should be emphasized that the waste oil should not be used to power critical equipment, such as pumps and generators, because of the potential for damage to engines by off-specification fuels.

3.2 Drum Cleaning

The drum cleaning operation involved injecting hot, high-pressure water into the bung opening of empty 45 or 10 gal. drums to rinse any residual liquid oil or oil vapours. The objective was to eliminate any remaining environmental risk and reduce safety hazards from explosive vapours. A high-temperature pressure washer (HTPW) was used. Figure 3 is a schematic diagram showing the layout of the drum cleaning operation.

The procedure for this operation was as follows:

i) place an empty and open drum on the drum rack in the cleaning tank;

ii) insert the pressure washer spray wand into the large bung opening and clean the inside of drum;
iii) drain the water from the drum into the drum rack reservoir;
v) remove the drum from the cleaning tank;
vi) replace both bungs in the drum;
vii) periodically pump the oily water from the drum rack reservoir; and,
viii) periodically remove the cleaned drums to the ship.

The procedures and equipment used worked very well; it was possible to clean between 25 and 30 drums per hour. There were 187 empty drums at the site already, which were taken approximately 40 at a time and cleaned along with the newly emptied drums. All 482 drums had been cleaned by the end of the operation. The operation was most efficient with four or five workers. The emptying and cleaning operations proceeded much faster than the oil could be burned. The same four workers emptying the drums could also clean them.

FIGURE 3: Schematic diagram of drum cleaning site
In order to contain any aqueous discharges, the cleaning was performed in a 3 m square porta-tank. Plastic spray curtains were erected on three sides around the tank to contain water spray. Plywood was laid down in the bottom of the tank to protect it from the steel drums.

Fresh water for the HTPW was pumped approximately 50 m from a nearby stream to an open-top porta-tank near the cleaning site. Almost all of the drums had rust and dirt in the bottom and large quantities of oily, rusty water were produced during the cleaning operation (about 3,200 L). Approximately 2,500 L of this was disposed of with the SAACKE burner (see Section 3.3); the remainder was transferred to the ship. A drum rack in the middle of one end of the tank held the empty drums while they were being cleaned. The drum rack had a built-in reservoir beneath it that could contain 455 L of liquid. This was typically filled after 50 to 60 drums had been cleaned. Periodically, the water was pumped from the drum rack reservoir to another porta-tank located uphill from the burners.

A steam generator was specified in the original equipment list but was unavailable and two HTPW's were supplied as replacements. It is unclear as to whether the HTPW's performed better or worse than a steam cleaner would have. A steam cleaner would almost certainly require less water, thereby generating less oily waste. Also, due to difficulties with the calibration of the gas sensing meter (explosimeter), it was not possible to determine the concentrations of hydrocarbon vapour in the cleaned drums, and thus the effectiveness of the cleaning process in reducing safety hazards. This should be addressed in future operations.

On the third and fifth days of the operation, cleaned drums were transported to the ship in cargo nets slung beneath the helicopter. Between 15 and 18 drums were carried in one load. The drums were stored on the mid- and aft-lower deck of the CCGS Sir John Franklin, occupying a considerable space. Without the support of the Captain, and the large storage capacity of the ship, it would not have been possible to remove the drums from the site. This would have been unfortunate because although the major environmental problem would have been dealt with (i.e., the leaking fuel), the secondary problem (i.e., the unsightly, rusting drums) would have persisted.

3.3 Waste Fuel and Oily Water Disposal

The waste-oil was disposed of using two rotary-cup flare burners: the SAACKE SKV-150 and the smaller SWIRLFIRE Mk. I. A key goal of the project was to assess the capability of these burners to flare the waste oil quickly and cleanly (i.e., without smoke). Some of the samples taken prior to conducting the site cleanup (Meakin 1994) showed trace concentrations of PCBs and lead. These findings, and the proposed disposal method of flare incineration, were reviewed by Environment Canada and by the Environmental Protection Branch, Department of Renewable Resources of the Government of the Northwest Territories. Both agencies were satisfied that the concentrations of contaminants were well under regulated levels, and that the blending that would take place in the pillow tanks would reduce the levels further. Environment
Canada also indicated that the SAACKE and SWIRLFIRE burners surpassed regulated requirements.

Figure 4 is a schematic diagram showing the location of the burners at the site. Figure 5 shows the two burners in operation. The waste-fuel for the burners was supplied from the two pillow tanks. The tanks were connected to the burners through a series of valves and transfer hoses that permitted the operator to direct the flow of fuel from one or both tanks, to either or both burners.

The SAACKE performed extremely well during the project and accounted for 39,000 L of the waste fuel disposed, in only five days of operation. The average fuel disposal rate over the entire operation was 800 L/h and the maximum achieved rate was 1110 L/h. The site and waste fuel characteristics were well suited to this burner. The SAACKE supplies only 25% of the stoichiometrically required air for combustion and provides the remainder by directing the available wind into the flame (Buist 1982). Although the burner is very sensitive to both the speed and direction of the wind, the breeze at Alexandra Fiord was steadily onshore for four of the five days; this, coupled with the excellent burn characteristics of the waste fuel (mostly volatile av-gas), made for a very clean flame with no visible smoke.

**FIGURE 4: Schematic diagram of burner site**
FIGURE 5: SAACKE and SWIRLFIRE burners in operation
The SAACKE disposed of all but a few drums of the oily water produced by the drum cleaning operation (about 2,600 L). Approximately 2,200 L of the oily water was siphoned into the fuel-feed stream for the SAACKE burner through a tee at the control panel. Flow was controlled (and crudely regulated) by a ball valve on the tee. The gear pump in the SAACKE control panel provided enough agitation for the fuel and water to be well mixed. The addition of water in this manner caused the flame to appear very luminous and clear, and somewhat shorter in length (approximately 2 m as opposed to 3 m). Feeding the oily water through the burner ensured that all hydrocarbons were completely destroyed.

On the last two days of operation (Sept. 3 and 4) the SAACKE burner showed a marked decrease in throughput (600 L/h from 1100 L/h). The cause was likely fine rust and debris particles clogging the pipes and valves of the control unit, and the fuel injection port of the burner. The debris could have entered the burners either via the emptying operation, being carried with the fuel (see Section 3.1), or via the cleaning operation, being carried with the oily water (see Section 3.2).

For future operations, a screen liner with a finer mesh than the existing filter should be added to the SAACKE control unit to prevent contamination of the burner. In addition, a fine filter in the waste-water line should be included in the drum cleaning equipment. Another alternative would be to consider some form of settling tank for the waste water, depending on whether the cleanup operation timeline would allow enough residence time for the solids to separate.

As an experiment on the last two days of the operation, approximately 600 L of oily water from the cleaning operation was pumped into three open-top drums in front of the SAACKE. The objective was to test an alternate method of disposing of the oily water. The intense heat vaporized and ignited all of the oil floating on top of the water, and boiled off approximately half of the water in each drum after six hours of burning. Although the heat was very intense, the exposed surface area of the drum top was small and evaporation of the water was slow. This method of disposal could be made more effective if large, shallow metal trays were used in front of the burners. The larger surface area would allow the liquid waste to be vaporized more quickly. This method of disposal would reduce the possibility of solid contaminants fouling the burner.

On the fifth day of the operation, the remaining oily water (approximately 700 L) was pumped into three drums and transported south for disposal. It was decided not to feed it through the SAACKE burner for fear of exacerbating the decline in throughput.
Although the SAACKE burner can handle water that is well mixed with fuel without extinguishing, it cannot deal with slugs of water. On two occasions, small amounts of water from the bottom of some of the waste fuel drums were pumped through to the pillow tanks, and then to the SAACKE burner. The water extinguished the flame in both instances; however, the SAACKE was quickly reignited and the water caused no further difficulties.

For the periods that it was operating, the SWIRLFIRE performed well, with a smokeless throughput estimated at 140 L/h. The flame produced by the SWIRLFIRE was more contained by the burner head and was not as susceptible to shifts in the direction of the wind, or to slugs of water in the fuel, as the SAACKE’s flame was.

Unfortunately, the SWIRLFIRE encountered mechanical problems and, as a result, accounted for the disposal of only 700 L of waste. The problems centred around the rotating seal that connects the non-rotating waste-fuel injection line to the rotating shaft and cup. The seal was not machined according to the manufacturer’s specifications and has leaked from the very beginning (S.L. Ross 1989). Repairs have been effected several times during the life of the burner and three times during the project, but all failed to correct the problem completely. Because the leak posed a fire hazard, the use of the burner was curtailed. The rotating seal on the SWIRLFIRE should be replaced by the manufacturer. Once that is done, the unit should perform well and should be considered for future oil disposal operations because of its compactness and good design features.

The SAACKE burner requires considerable logistical support to move, setup and operate, due to its large size and weight. It is unlikely that it could be used at a site not accessible by sea or large aircraft. The smaller SWIRLFIRE unit, while considerably simpler from a logistics viewpoint, is still somewhat too large to fit into a DHC-Twin Otter. The Twin Otter is the aircraft of choice (and in many cases the only choice) for flying into many sites in the Arctic. The construction of a new burner, based on the design of the SWIRLFIRE, but Twin Otter-transportable, should be considered.

### 4.0 EQUIPMENT DEMOBILIZATION

On the final day at the site, the three remaining drums of diesel fuel were emptied and the contents burned. For safety reasons, it was arranged that the diesel be the last fuel through the system to wash out any higher volatility av-gas. Once the diesel was burned, the equipment was taken apart and repacked. This required about six hours. The equipment was loaded onto the ship in the late afternoon. The vessel returned to Resolute Bay on the afternoon of September 6.

Along with the empty fuel drums there were other materials removed from the site. These included approximately eight open-top drums containing scrap metal, several car batteries and the empty metal and plastic 1 qt. lube oil containers. The three drums of oily water from the cleaning operation that had not been passed through the burner were also loaded onto the ship, and were disposed of in St. John’s.

Approximately 1.5 bales of sorbent pads were used to clean equipment and mop up small
spills. Also, there were ten slightly oiled sorbent socks from the portable containment platforms at the emptying site and the berm around the pillow tanks. Since the sorbent pads and socks were made of a polymeric material, they were not incinerated and were loaded into garbage bags and taken south for disposal. It is recommended that consideration be given to options for reducing the volume of waste sorbents in future operations.

5.0 REFERENCES


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