CROSS-FIRE: Green Thermal Desorption With a Focused Blue Flame

by Tom Maleck, CROSS-FIRE Soil Remediation LLC

During the environmental clean up at a property that has hydrocarbon contaminated soil, expenses and costs can rapidly spiral out of control for property owners. It is not just clean-up costs that get out of control; when this contamination is taken to an off-site treatment or disposal facility, the responsible party may have just extended its liability. Many contaminated sites being cleaned today are, in fact, former disposal facilities that have failed due to off-site migration of contaminants or poor business practice of the disposal or treatment facility. The individuals that had contaminated soil taken to these locations are now financially responsible for a portion of these clean-up costs under today's "cradle to grave" legislation.

Heating contaminated soil to burn off contaminants is not a new idea; since 1985, thermal desorption has allowed for the on-site soil remediation. However, thermal desorption is, in almost all cases, cost prohibitive, and its use is almost always confined to very large budget soil clean-up operations, such as Superfund sites. After a very high mobilization cost, the complex systems require a considerable amount of time to set up and need a large area in which to operate. These thermal desorption and off-gas systems consume an incredibly large amount of fuel (propane or heating oil) to remediate contaminated soil, piling on additional – and potentially spiraling – costs to the project.

Now the cost of cleaning up contaminated soil may be greatly reduced thanks to the development of the Cross-Fire soil remediation system, consisting of a proprietary add-on thermal desorption unit (TDU) and a patented process involving the use of a commercially available aggregate mixing trailer or portable asphalt pug mill. The process utilizes eight high temperature, low-BTU burners that focus hot blue flame on aggressively mixed contaminated soil. The Cross-Fire soil remediation system delivers truly "green" thermal desorption, in terms of both environmental and economic impact.

The CROSS-FIRE unit feeding a stacker conveyor, returning cleaned soil to the excavation. As much as 45 tons of contaminated soil can be cleaned in an hour.

Cross-Fire's Advantages

When attached to a portable aggregate mixing trailer or pug mill, the Cross-Fire TDU changes the use and purpose of the pug mill. The Cross-Fire TDU is an add-on device that can be transported in the bed of a pick-up truck. A portable pug mill can be taken to a soil remediation site with the aid of a semi-truck. Once on site, the pug mill occupies a footprint of 45 feet by 8 feet, or about 360 square feet. The Cross-Fire TDU is placed over the mixing pug and the on-site footprint remains the same.

The Cross-Fire TDU consumes propane at about 15 gallons per hour, (GPH), which is less than 2.8% of the fuel BTU requirement for an asphalt plant, and about 13% of the fuel required to run a thermal screw. Burning this amount of fuel to treat a similar amount of soil indicates that even if the other devices were as clean-burning, they emit a CO and CO2 load to the atmosphere 20 times that of Cross-Fire.

The Cross-Fire Soil Treatment Path

Maximum soil mixing and aeration achieved

In the pug mill, the soil is aggressively aerated and mixed with twin rotating shafts that typically have 12 pairs (24 paddles) of mixing paddles on each shaft. During this process, the Cross-Fire TDU engulfs this nearly particulate sized contaminated soil with its focused blue flame in direct contact with the soil. The temperature in the flame's reaction zone reaches 2,900 degrees F; the blue flame is an indicator that there is complete combustion of the purge gas (propane). The burners operate at a hotter temperature, and burn cleaner than most afterburners required on large thermal desorbers that often consume more than 20 times the fuel as the Cross-Fire TDU.

The multiple burners on the Cross-Fire TDU are naturally aspirated utilizing gas phase propane and atmospheric air. (Propane is an approved, alternative clean fuel listed in the 1990 Clean Air Act, as well as the National Energy Policy Act of 1992.) The burners are not blown, as in nearly all other thermal desorption devices. These multiple downward firing burners engulf the contaminated soil, which is being tossed into the flame's hottest area, its reaction zone.

Case Study: On-site Soil Remediation, Eddington, Maine

In October 1998, during a soil removal project in Eddington, Maine, it looked like there would be approximately 80 to 100 cubic yards of gasoline contaminated soil when the service island was removed. Problems began when, in the process of removing the piping from the top of the underground tank, it was found by the licensed tank installer that the piping was on hand-tight. At the same location, there was a check valve that was also very loosely attached. In this situation, this location most likely leaked product into the ground from 1983 until 1996, when the convenience store ceased operation.

About 11 months earlier, a pug mill operator and job foreman considered using a pug mill for contaminated soil. The idea was to mix the contaminated soil and use a binder or extender liquid to "bind" the soil contamination. While this process had been used with mixed success, there are many restrictions on its use; soil should not be returned to an area where it is in the water table, and it is recommended that this "bound" contaminated soil be used under areas that are to be paved over.

Since these conditions did not exist, alternative methods were tried to clean the soil in a cost-effective manner. Since a pug mill was on site, the highly contaminated soil was run through the mixing pug, and some drop was noted in the level of contamination of the soil. However, this small amount of soil was processed three times before it was near the established clean up level of 1,000 PPM on the Photo Ionization Detector (PID).

Using the Cross-Fire TDU, it was possible to remediate more than 1,500 cubic yards of high moisture clay to silty clay, glacial till soil that had an initial contamination level greater than the PID could measure. (All soil to be treated registered greater than 2,500 on the meter.) Through testing and varying the soil feed of the pug mill, results varied from non-detect to 200 on the meter.

All processed soil exceeded the established level of clean up. All samples were found to be less than 500 PPM on the PID. The soil processing rate at this location was between 33 and 36 cubic yards of contaminated soil per hour. A soil testing protocol was established to sample every 20 minutes for quality control measure.

When the Eddington site was cleaned up, the total savings was more than $60,000 over the conventional muck and truck method of excavation, hauling with a small fleet of dump trucks to a treatment or disposal location, and purchasing and trucking replacement back fill or soil to the site. It is also important to note that an estimated five to six dump trucks were not used, thereby reducing the nitrogen oxides and particulates at the construction location and over the removal route.

Note: An add-on thermal desorption unit for a common aggregate mixing trailer or pug mill was developed for this project; this unit served as a prototype of the Cross-Fire device.

It is important to mention that the Cross-Fire TDU and process generate no visible opacity (smoke) or visible soil particulates during the clean up. No post-treatment is required since the purge gas is consumed in the complete combustion of the clean burning treatment flame.

Soil treatment time

Soil treatment time and soil temperature are interrelated in that the same residual organic concentrations can be achieved at different combinations of these parameters. For example, a batch type thermal desorption system operating at a soil discharge temperature of 400 degrees F and 60 minutes residence time may achieve the same soil treatment criteria as one operating at a soil discharge temperature of 600 degrees F and five minutes residence time.

Treatment time in directly heated thermal desorption devices, such as rotary dryers, asphalt kiln aggregate dryers and the conveyor furnace, is generally less than 10 minutes. Treatment time is difficult to monitor than treatment temperature for these types of batch treatment devices.

Treatment time for the Cross-Fire TDU is even more difficult to monitor, as this type of thermal desorption is a departure from the batch type desorbers. Small amounts of contaminated soil are fed in a continuous stream through a highly aggressive mixing area that consists of twin rotating shafts with attached paddles (usually around 12 pairs per shaft). (Remember, this mixing and aeration is a function of the pug mill.) In the mixing pug, the soil is aggressively aerated while being thrown into the hot blue flame's reaction zone. The highly mixed, nearly particulate soil has its organic components stripped, volatized and thermally oxidized during its transit through eight such cross-firing burners that fire perpendicularly into the soil flow in the mixing pug.

Oxygen content of the purge gas

In most thermal desorption systems, the purge gas will be either oxidative or inert. For a direct-fired system, the combustion gas from the burner serves as a purge gas. The stream will always contain a significant amount of excess oxygen (flame will be yellow-orange). The organic content of the feed material must generally be limited to less than 2% to 3% to stay below the lower explosive limit if an oxidative purge gas is used.

The Cross-Fire TDU uses propane burners that are not blown. The burners obtain their ambient oxygen from air outside the combustion chamber/mixing area. Blue flame is a sign of complete combustion of the purge gas, which is clean burning propane. The atmosphere inside the combustion area is at or slightly below ambient oxygen content (it is neither oxidative nor inert). The organic content of the feed material can be higher than in thermal desorbers that are oxidative. ▲

Tom Maleck is the developer of the Cross-Fire soil remediation system. Prior to inventing the Cross-Fire Thermal Desorption Unit, he served with the Maine Department of Environmental Protection. During his 22-year career as an Oil & Hazardous Materials Specialist, Tom supervised the cleanup of hundreds of oil spills and their respective site remediations, averaging over 115 spills per year. For more information, please contact him at (309) 343-0345 or via e-mail at info@cleansoil.net