# AN INNOVATIVE APPROACH FOR CONTROLLING SOLID WASTE LANDFILL GAS AND LEACHATE

C. P. Edmunds
Shaw Group, Inc.

S. H. Kopp
Kopp and Associates

S. P. Sayers
PolyMaster, Inc.

## ABSTRACT

Solid waste landfills are sited, designed, and operated to minimize the possibility that the emplaced wastes will come in contact with groundwater or surface water. Additional controls are necessary to reduce airborne emissions such as particulates and methane gas and to protect wastes from disease-carrying vectors. Current landfill designs incorporate both single and multi-layered cell liners that use both synthetic and natural materials that provide an impervious barrier between the landfill and underlying soils. A leachate collection system is also installed for collection and treatment of rainwater that percolates through the wastes from the surface. As the cells are filled, exposed wastes are required to be covered on a daily basis to reduce access to wildlife scavengers and to minimize contact with the atmosphere and rainwater. When filled to their design capacities, the cells are capped with a final impermeable or semi-impermeable cover to minimize rainwater infiltration. After the landfill is filled with waste material, a gas collection system is often installed to collect and remove methane gas that is formed during anaerobic digestion of the wastes.

Despite these design and operational considerations, surface "breakouts" of entrained leachate and gas can occur which must be controlled throughout the life-cycle of the landfill, and can extend to as much as 20-years beyond the landfill's operational life. Clay soils are typically used for the final landfill cover however, cover materials are often porous and non-homogeneous. Clay materials suffer from fracturing during dry periods, and become "plastic" when saturated with water over long periods of time. When breakouts occur, it is often difficult to isolate the source of the liquid or gas. Conventional response measures often require the landfill operator to dig into the landfill, find and correct the source of the problem, and repair the outer cover. These measures often disturb other wastes in the process, exposing workers to elevated health and safety risks, and increase the risk of a release to the environment. Costs associated with repairs include mobilization and demobilization costs for transportation of heavy equipment, costs for materials, and labor for equipment operators and workers. Time needed for repairs can also be disruptive of ongoing operations, causing increased operational costs.

PolyMaster, Inc. has developed a patented approach that can effectively and economically control the escape of leachate and gasses from landfills. The technique uses a "plastic slurry" that is injected into the soil using a specially designed probe that directs a pressurized stream of a resin and catalyst into the affected area. The injected materials form a gelatin-like material within a few minutes that eventually hardens into a solid plastic media. The solid material is chemically inert and non-flammable, yet biodegradable and is therefore ideally suited for landfill applications. The plastic slurry is initially injected into the soil as a water-soluble liquid and flows into the cracks and crevices in the weakened soils. As the material gels and hardens, it seals both gas emissions and liquid discharges. Instead of using heavy equipment, the PolyMaster system is mounted on a skid that slides into the back of a pickup truck and requires only one worker to operate. Materials are delivered to the injection device using hoses

that can be as long as three hundred feet, providing excellent accessibility to trouble areas. Use of this approach avoids expensive, dangerous and often environmentally unacceptable practice of exhuming previously buried wastes to isolate and remediate sources of leaks.

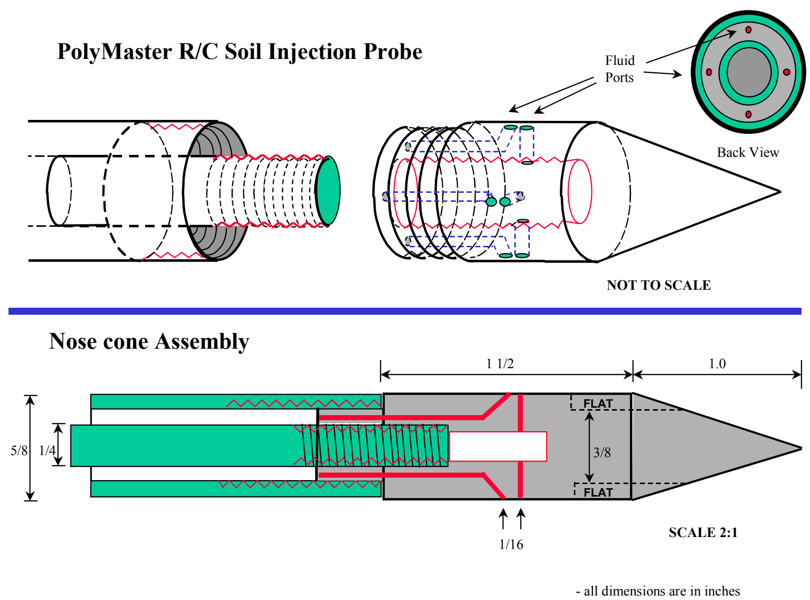
## INTRODUCTION

This paper discusses the development and composition of the plastic slurry material along with the design features and use of the injection equipment. Also discussed is how the PolyMaster system can be modified and used for other landfill applications. By varying the process, the plastic resin can generate a foam cover as an alternative to a six (6) inch daily cover of soil. The material can also be deployed as a dust control agent on haul roads, and can be used for erosion control and hydroseeding on final cell covers.

## DEVELOPMENT

The heart of this system is a kiln-dried urea formaldehyde resin that represents a third generation technology that has resulted in dramatic reductions in formaldehyde emissions from wood products. Unlike its predecessors, kiln-drying removes the free formaldehyde which causes off-gassing in the finished product, and results in a plastic that is inert and ideally suited to landfill applications because of its long-term biodegradability. Use of these materials for landfill applications date back to the mid 1980s when similar materials were used to replace daily landfill cover. During discussions with local landfill managers, PolyMaster learned that in addition to the need for alternative cover materials, there was also a need for a system to address gas and leachate breakouts, which are common problems in the landfill industry. In response, PolyMaster developed a simple, yet effective technique for addressing these problems. The process involves manual injection of the plastic resin and an inorganic catalyst into the soil where they combine and produce a gelatinous mixture that eventually cures into a glass-like plastic. As the resin gels, open pores in the soil are filled, restricting the flow of gas or leachate to the surface. When cured, the plastic acts as a soil amendment that strengthens the surrounding soil. Over time, the material degrades allowing the cover to regain its original flexibility.

Development of a cost-effective alternative required design of a simple tool for injection of the plastic resin and catalyst into the target soils. Because reaction times are very fast, a soil injection device needed to be designed in a manner to keep both materials separated prior to injection. However, once the materials are injected, the materials have to mix at an equal ratio to generate the polymer. The solution came in the design of a simple soil probe that has been patented by PolyMaster for this application. A schematic of the probe is provided in Fig. 1.

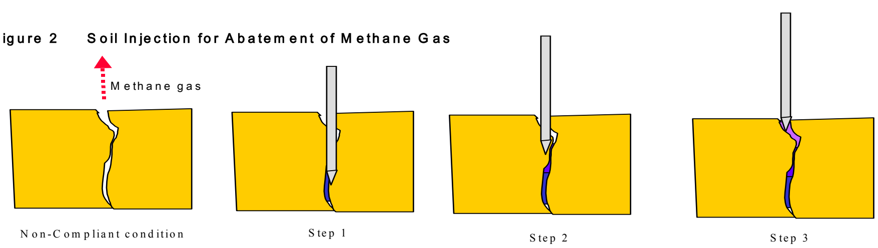



The resin and catalyst are separated by an inner and outer casing and mix immediately on exit from the soil probe. The injection angles are designed such that material is delivered laterally in a 360 degree angle around the probe.

The probe is approximately four-feet in length and is manually driven into the soil. The materials can be injected either simultaneously or sequentially depending on the nature of the application. After a suitable injection device was developed, the material formulations and injection techniques were adjusted to provide optimum performance in the field.

The injection technique is basically the same for both leachate control and gas abatement. The probe is inserted to a depth of two to three feet and material is injected into the soil. A period of three to five minutes is allowed for the injected materials to gel. The probe is lifted approximately one-foot and additional material is injected. The process is repeated until all of the soil in the vertical column has been treated. This process is illustrated in Fig. 2

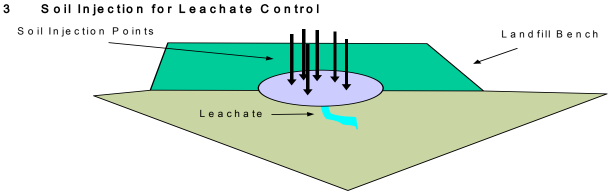
Figure 2 Soil Injection for Abatement of Methane Gas




The same procedure is employed for leach breakouts, except that multiple injection points are used to saturate the affected area with material. A typical injection scenario is presented in Fig. 3. Injections are started upgradient from the breakout. As the affected area is approached, polymer and catalyst displace the leachate and begin to gel. Once the soil has been saturated the material will eventually harden, adding strength to the weakened soils.

During development, Browning Ferris Industries, Inc. (BFI) provided PolyMaster with access to a closed landfill in the Knoxville, Tennessee for field testing and of the application for leachate control and methane gas abatement. Following development, a demonstration was performed, and was reviewed by state regulators. Success of the application and approval by regulators has led to deployment at a limited number of landfills. Based on the application's successes, PolyMaster now offers this approach as a proven technology for use as an effective alternative for leachate and gas control.

Figure 3 Soil Injection for Leachate Control




## REGULATORY BACKGROUND

Landfill management requires implementation of operational measures to minimize releases of methane and leachate to the environment. Such releases add to air pollution indices and can pollute surface water that comes in contact with leachate. Failure to correct these problems when they occur can result in fines of up to $5,000 per day for each day of non-compliance. Landfills are subject to routine inspection by regulators and any non-compliant conditions are reported, allowing reasonable time for correction. Non-compliant conditions generally include visible leachate breakthrough, and point-source methane gas emissions above 500 ppm. Most landfills are operated with leachate and gas removal systems, however, outbreaks will occasionally occur. These outbreaks are often related to either unusually wet, or unusually dry weather periods. Clay soils become plastic when saturated with water and can create thin spots in side walls where accumulated water percolates through to the exposed surface. During dry periods, clay cover materials will desiccate and shrink allowing gas to escape from fissures in the soil. Problems with gas and leachate collection systems can result in increased releases, which require control. As current problem areas are corrected, new ones develop because the contaminants simply move to a new location. These dynamics mean that managing releases, and therefore compliance, is a continuing process.

## TECHNICAL CONSIDERATIONS

### Physical Properties of Materials

A water-soluble resin and catalyst are used to generate the plastic material, and are injected in equal proportions into the soil. The resin is supplied as a wettable powder that is mixed with water to form a solution for injection. The catalyst comes as a liquid concentrate that is also mixed with water prior to use. A pump unit delivers each of the materials to the injection probe which is controlled by separate valves for the two liquids. The pumps, mixing unit, and hoses are all mounted on a skid that can be placed in the bed of a standard pick up truck. A generator supplies power for operation of the pumps. Up to 300 feet of hose can be used to connect the pump unit to the injection probe.

Catalytic action is provided by a mild acid with a pH in the range of 3-4, and is similar to the acidity expected in landfill leachate. The acidity is immediately neutralized when it comes in contact with the resin and polymerization occurs. Because the resin is catalyzed by the prominence of excess hydrogen-ion, (i.e.acid-activated), the levels of acidity expected in landfill leachate is sufficient to complete the polymerization process if excess resin is inadvertently injected into the landfill.

A gelatin-like material results within five to ten minutes following catalysis, and eventually hardens into a glass-like plastic as cross-linking is completed.

The plastic material is both inert and non-flammable, however, the nitrogen base of the polymer makes the plastic biodegradable when it is introduced into the root zone. This property of the material yields itself to the dynamic nature of the landfill cover over time. When a foaming agent and compressed air are added, a plastic foam is produced that meets the RCRA definition of a solid inert material for use in closure of underground storage tanks.

**Equipment Needed**

PolyMaster provides a complete skid-mounted system that fits in the bed of a pick up truck. This system is fully self-contained and includes a generator for remote operation. The system is completely portable and is simple enough for use by one operator. A source of water for mixing of the materials is the only additional resource needed. An air compressor can also be added if foam is needed for special applications such as erosion control or daily cover. By comparison, conventional control techniques require the use of heavy equipment that at minimum include an excavator, dump truck, and grader. If bentonite, or other materials are needed, deliveries must be coordinated in conjunction with the repair. Equipment mobilization must also be factored in if repairs are made at a remote, or off-site location. If additional equipment are not available, costs will be incurred for equipment leasing, or on-going operations will need to be disrupted to make the repairs.

**Safety of Operations**

Generally, one worker is all that is needed for the soil probe process and can be completed in its entirety in a single afternoon. Often, access to the problem area can be gained with a light-weight pick up truck without driving on fragile benches, inclines, or the cover itself. Material supply hoses can be as long as 300-feet and allow equipment with potential sources of ignition to be operated at a safe distance from the area being injected. The most important safety consideration is that the soil cover is not disturbed and workers and equipment are not exposed to buried wastes. Potential releases of contaminants to the environment are also reduced or eliminated because wastes are not exposed.

## CASE STUDIES:

## METHANE GAS ABATEMENT

The technique has been successful in reducing individual methane leaks measuring as high as 30% methane to levels below a regulatory criteria of 500 ppm.

Methane is a natural by-product of anaerobic digestion of organic wastes, and can become trapped in pockets or layers between courses of daily soil cover. Because methane contributes to air pollution, inactive (i.e. closed) cells are fitted with a methane gas collection system consisting of a series of wells installed vertically into the waste. A slight vacuum is maintained on each well to extract accumulating methane which is directed to a thermal oxidizer, or gas recovery system. Often individual pockets of methane develop that cannot be effectively collected, or extraction dynamics change to the extent that extraction is no longer efficient. The buildup of gas eventually finds an escape route to the surface through the soil cover. These outbreaks usually occur during warm and dry periods when methane generation is higher, and clay cover materials desiccate, causing small fissures in the cover where gas can escape.

Landfill operators are required to perform periodic inspections of active and inactive landfills, and are required to address any outbreaks of methane gas that are encountered. In addition, regulators perform routine inspections of landfills for methane gas emissions. A calibrated methane gas detector is used to measure emissions. The operator or inspector usually walks across the cover in a "serpentine" pattern and investigates any anomalous areas. Any outbreaks exceeding regulatory limits are flagged as a point of non-compliance, and require attention by the landfill owner within a specified period of time.

During development, PolyMaster was provided with permission to access a closed landfill east of Knoxville, Tennessee known as the Twin Oaks landfill. At the time of development in the summer of 2000, the landfill had been closed for a period of 5-6 years and was actively producing methane. A gas collection system had been installed along with a thermal oxidizer to control emissions. At the time, the gas collection was not operating efficiently and some gas outbreaks were occurring. Following are two examples where the soil probe technique was employed.

## Methodology

All gas measurements were made using an MSA GasPort analyzer that was calibrated according to the manufacturer's specifications. Calibration verifications were performed prior to each use. Measurements were taken two inches from the soil surface in accordance with procedures used by state regulators. Multiple readings were taken at each location to verify the source of methane emissions. Marker flags were used to identify methane sources, and included dates of inspection and/or treatment. Field information was documented, and included a scetch of the area, weather conditions, gas readings, and any relevant observations. Initial and final gas readings were taken during each field activity.

Soil injection followed the process illustrated in Fig. 2, by manually inserting the soil probe into affected soils, or directly into the fissure where gas is escaping. The technique is best accomplished by starting at a depth of two to three feet, injecting, and allowing the material to gel. The probe is then lifted and the process repeated as necessary. Multiple injections of 20-30 seconds may be required to fill cross channels, holes, etc. A final injection of material is released at the soil surface to seal off the cavity. Once the plastic has gelled, a light covering of soil can be placed over the injection point to physically protect the surface.

### Site 1- Random gas leak along landfill bench access road

This leak was discovered by an employee of BFI following a period of heavy rainfall. At the time of discovery the escaping gas was audibly "gurgling" through water that had collected in the vent hole measuring approximately 1-2 inches in diameter. On 7/06/03, the gas concentration was measured at >1800 ppm (estimated 28-30% methane 30,000 ppm). The soil probe was inserted to a depth of approximately 2 feet and equal volumes of resin and catalyst were injected. An injection time of approximately 20 seconds was used. At material flow rates of approximately 0.8 gallons per minute, a total volume of 0.5 gallons of resin and catalyst were injected. Subsequent gas readings of <100 ppm indicated that the vent was sealed. The set time for the resin was approximately 5 minutes. Additional gas readings were taken, and all were <100 ppm at the soil surface. The area was covered with dirt and re-contoured by BFI personnel prior to 7/10/00 when the location was re-inspected by PolyMaster. No measurable methane could be detected at the original location, or within the immediate area. Following treatment, no gas has was detected at this location. During a later inspection by PolyMaster on 7/26/00 a gas leak was discovered along the same road approximately 125 ft west of well 21.

Under the state's regulatory policy, methane gas outbreaks are regulated as point-source emissions, therefore the outbreak discovered on 7/26/00 constitutes a new event. According to regulators, if the location of the source moves any amount, it is considered a "new" source. From a practical perspective, however, effective control requires abatement of gas emissions from an area within an approximate 5-6 foot radius of the original source.

**Site 2 Area of multiple gas leaks near gas well 27**

This area was originally treated on 6/22/00 using a preliminary design of the soil injection system, which included separate injectors for the resin and catalyst. This approach was found to be only partially effective. On 7/06/00 three gas vents measuring approximately 0.25 to 0.5 inches in diameter were sealed using the re-designed system. Initial gas readings for each of the vents was >1000 ppm. Following injection gas readings at all three points were between 100-300 ppm at the surface, meeting the state's action level of 500 ppm. Accurate readings could not be obtained because of high background levels of methane in the immediate area.

Additional monitoring and treatment was performed in an adjoining area, measuring approximately 10 feet by 30 feet. Methane at this location was percolating to the surface through a large number of small and large fissures. Visual observations indicated that the area had previously been under water. At the time of the observations on 7/06/00, the clay surface was beginning to fracture as the result of drying. Methane concentrations were variable, often exceeding the 500 ppm action level. Based on the observations, gas emissions from this area were believed to be responsible for the high background readings previously observed. Control of methane from this location was considered unsuccessful because gas readings in the immediate area could not be reduced to below 500 ppm.

Because of the size of the affected area, treatment using a single soil probe proved to be ineffective, indicating that a more robust responsive measure was needed. It is possible that development of a multi-point injection system capable of treating a larger area would be helpful..

## Comments

The large area where the gas abatement trial was unsuccessful is likely a worst-case situation, which is not typical of the measures needed to maintain compliance with regulations. According to BFI staff, the problem area had been identified as one where an additional gas-removal well was needed.

A colorant can be needed to help blend in the normally white plastic with surrounding soil, making treated area less noticeable. The response from regulators however, is that the white coloring is helpful to demonstrate that corrective measures have been attempted. Following acceptance by regulators, a final step in the process should include covering with 1-2 inches of soil to protect the plastic from direct exposure to the environment.

Following development of the application in the summer of 2000, the soil injection technique has been used by PolyMaster on a limited basis to further prove the process. To date, the soil probe system has been used at four different landfills located in east and middle Tennessee operated by both BFI and Waste

Management, Inc. More than 30 gas leaks have been addressed, and to date, all have been successful. Charges for equipment, materials and labor have been less than $200.00 per application, and include mobilization for an average service distance of approximately 45 miles.

Based on these case histories, the following advantages have been identified:

- **Increased Safety, Lower Cost of Repair, Convenience, Regulatory approval**

  Advantages include increased safety and lower cost for maintaining property. The injection process requires only minor disturbance of the soil surface. Because equipment with ignition sources can be kept at a safe distance from methane release areas, the technique significantly reduces the risk of fires or explosions because of exposure to flammable levels of gas. The polymer materials used do not react with methane and do not produce heat during the polymerization process which increases worker safety during injection. Once formed, the plastic polymer is inert and will biodegrade over time.

## LEACHATE CONTROL

The soil probe described in Fig. 1 has proven to be an effective means for controlling leach breakouts in the side walls of landfills. Modern landfill designs include a leachate collection system to remove infiltrated rainwater, or groundwater, that has collected above the clay or membrane liner beneath the landfill. Often, collected water will become perched on intermediate soil layers, causing it to seep into the sides of the landfill. Erosion and other factors can weaken the outer berms of the landfill allowing collected water to seep through. Breakouts usually occur following periods of heavy rainfall, and can be difficult to spot until surrounding areas dry out. Problem areas initially appear at the base of the landfill as areas of wetness, and may be accompanied by visible discharge, discoloration, or excessive plant growth. The soil probe technique does not address situations where leachate may have penetrated the bottom liner of the landfill. The soil probe is however, well suited to injection of materials into the side walls and base of the landfill where soil thicknesses average between 4 to 6 feet.

Landfill operators have the same responsibility to inspect landfills for leach breakouts and repair them in a timely manner to prevent off-site releases, or contact with surface water.

### Methodology

Leachate breakthroughs are effectively identified through visual inspection, however, infrared imaging can be a useful tool for early identification of problem areas. Although good success has been achieved using the soil probe technique, early treatment is still the key for cost effective control.

The injection process is the same as for gas abatement (Fig. 1), except that multiple injection points are used as illustrated in Fig. 2. The most effective technique is to begin upgradient from the breakout, and eventually surrounding the impacted area. A large breakout will use as much as 20 gallons of material to fully saturate the area. As the material gels, pores in the soil become plugged, reducing the flow of leachate. The plastic material in the saturated soils will eventually harden, adding additional strength to the weakened surfaces.

The following case study describes the treatment of a leach breakout that was performed on 07/18/2000 at the Twin Oaks landfill operated by BFI. The treatment was performed during the development stages of this technique.

**Well 4 Leachate - Leachate Breakout near Twin Oaks, Well 4, Lower Bench**

This location was identified to PolyMaster by BFI personnel as representative of a severe leachate problem that was "very difficult" to fix. Three previous attempts to fix the breakout using conventional (i.e. bentonite/soil cover) techniques had already been made prior to the June-July time frame when PolyMaster's field trails were begun using this technology. Previous repairs included excavating through the sidewall of the landfill to the exposed waste, filling in with bentonite clay, and covering with a protective soil layer of clay. On July 06, following the final repair in mid June, active leachate was observed at the center of the repaired area. This area impacted by the leachate was injected using the soil probe. The area of the breakout was covered with additional soil by BFI personnel during the period between July 06 and July 10. When re-inspected on July 10, leaching at the center of the covered area had subsided, and the area was drying. During the period between July 10-18 leachate re-appeared along the left perimeter of the repaired area, at the junction between the disturbed and un-disturbed soils met. This new area of wetness was approximately 6-ft from the previous location. The new area was then re-injected on July 18 using the same soil probe technique. Observations made on July 24-26 indicated that the no leaching was occurring from the repaired area, or from the perimeter around the repaired area. It was concluded that the repaired area had now sealed and was drying. Wetness was again noticed during observations made on August 14, however, these observations were made following a period of wet weather. When re-checked on August 18, the area was once again observed to be drying.

**Comments**

The challenge at this location was that conventional repairs using excavation and packing with bentonite had been attempted without success on three previous occasions. Because this was a closed landfill, the landfill operator had been required to mobilize heavy equipment, materials, and labor to the site for each attempted repair. Within a few days following the last repair, moisture was already appearing in the center of the repaired area. In contrast, one worker with a truck-mounted soil injection system was able to effectively stop the new breakout that was forming in the center of the repaired area. During monitoring, another new discharge was observed at the outer edge of the repaired area which, logically, was the next-weakest point in the side wall. Subsequent treatment of this area proved to be effective in stopping the breakout at this location.

Initial development of the leachate application was performed in the summer of 2000. Since then, PolyMaster has used the technique on a limited basis on two occasions. In both instances, the breakout was stopped at the original location, but then moved to a new location in the immediate area. Average costs have been less than $500, including operator time and mobilization from PolyMaster's Knoxville, Tennessee office.

Based on the case studies that have been performed, PolyMaster believes the technique will provide more effective control if breakouts are treated in their early stages of development. PolyMaster is exploring the use of thermal imaging to identify areas of wetness indicating newly forming breakouts. This element would make the this technique more pro-active, however, it would require monitoring and/or treatment, using thermal imaging on a monthly, or more frequent basis to be effective.

As a leachate control measure offers the following advantages:

- **Increased Safety, Lower Cost of Repair, Convenience**

  Advantages are similar to those for methane gas abatement, and include increased safety, and lower cost for maintaining property. The injection process requires only minor disturbance of the soil surface, and does not expose worker to buried wastes. The technique also minimizes the risks of fires or explosions because of exposure to flammable levels of methane gas. Since the polymer is inert, it does not react with contacted wastes or generate heat.

## DAILY LANDFILL COVER

By modifying the formulation of the catalyst and adding compressed air, a plastic foam can be generated that is easily applied to the surface of deposited wastes. The foam offers the temporary protection needed to effectively isolate wastes from the environment, and becomes incorporated with the waste layer as new wastes are added. Plastic foam has been used by a small number of landfill operators as a substitute for soil cover since development of this technique by 3-M Corporation in the late 1980's. By replacing the non-compactable soil used for daily cover with foam, as much as 15% of total landfill volume is gained for accumulation of wastes. Use of foam as a daily cover is also cost effective in areas where soil is not readily available, or of poor quality to serve as a daily cover. Because landfill space is becoming more valuable, PolyMaster is re-addressing use of foam for daily cover as a viable alternative to soil.

A demonstration was made in late May, 2000 at the BFI landfill located in Rodgersville, Tennessee. A two-inch layer of fully-expanded foam resembling shaving cream is sprayed uniformly over the waste using a truck-mounted spray system. A single unit can cover up to 6,000 square feet of waste per hour. The foam forms a hard outer crust that sheds water and protects the waste until new wastes are added on top. When crushed, the foam is easily biodegradable, becoming part of the waste layer itself.

### Technical Considerations:

Requirements for alternative daily landfill cover materials are found at 40 CFR 258.21(b), "Alternative materials of an alternate thickness (other than at least six inches of earthen material) may be approved by the Director of an approved State if the owner or operator demonstrates that the alternative material and thickness control disease vectors, fires, odors, blowing litter, and scavenging without presenting a threat to human health and the environment."

### Important properties of foam based on CFR requirements:

**Vector/disease control** - Formaldehyde is commonly used as a pesticide because of its action as a fungicide and bactericide. While the formaldehyde content of the applied foam is minimal there would likely be some benefit for the mitigation of fungi/bacteria that could be propagated by air to off-site receptors. Past experience indicates that cured foam is not attractive to insects, and can be made inhibitive by addition of commercial pest control materials if necessary.

**Fires** - Generated foam is considered non-flammable, and will not support combustion.

**Odors** - A 2-3 inch layer of foam has a low permeability to air and moisture flow, which is sufficient to control odors from the covered wastes.

**Control of blowing litter** - Because foam is applied wet, it has a bulk density of 2-3 pounds per cubic foot which is sufficient to effectively cover nuisance items such as polyethylene laundry bags. Wet application also allows foam to effectively cover non-uniform surfaces and unusual shapes.

**Scavenging** - The foam surface cures to a crusty material which will last in the environment for 2-3 weeks depending on weather conditions. The crusty surface minimizes scavenging, until disturbed by additions to the foamed surface. The foam is chemically inert, and presents no danger to human health or the environment.

**Biodegradable** - The cured foam is easily crushed when new materials are added to the foamed surface of the landfill. Crushed foam returns to the soil as a coarse powder which is biodegradable, therefore no landfill volume is lost to addition of non-compressive cover.

### Observations and Comments

A tentative cost analysis was performed which indicates that use of foam for daily cover instead of soil is an economical alternative. For example, the per-acre cost of soil to provide a 6-inch soil layer ($13/yd) is $10,419 compared to $6-8,000 for a 2-inch layer of foam. This translates to at least a 20% cost savings based on the cost of soil alone, which over a month of operation could result in a cost avoidance of $50,000 per month, or more, per acre being covered.

## OTHER APPLICATIONS

### Erosion Control

Soil erosion is a continuing concern at operating landfills where newly exposed soils are common. It is impractical in many ways to physically cover, or vegetate soils that will only be temporarily exposed until the final cover is in place. A solution may be to cover these areas with foam, which will promote water runoff, and protect the soils from erosion. PolyMaster is currently developing a foam-fertilizer that can be sprayed directly on exposed soils for use as an erosion control media. As the foam weathers, it acts like a sponge to trap water needed for early seed development. Once new seed are established, the foam provides added nutrient for the vegetative cover. The expected cost to foam a 100 square foot area is estimated at less than $5.00, and uses the same equipment supplied for gas and leachate control, with the addition of a foam gun and air compressor. A half-inch layer of foam is sufficient for erosion control and can be applied at a rate of 24,000 square feet per hour.

### Dust Control

Control of fugitive dusts from access roads is another problem that must be controlled by landfill operators. During periods of dry weather, water must be applied to roads frequently to reduce nuisance dust emissions. When a more dilute solution of water and resin is applied to the road surfaces, the adhesive properties of the resin act to bind the soil particles together. Without the addition of the catalyst, the resin remains hygroscopic for a longer period of time, and eventually cures into a hard inert material that is more difficult to re-suspend in the air. Addition of the resin to water sprayed onto the roads reduces the number of applications needed to control dusts during operations.

## SUMMARY

The applications that have been presented represent on-going concerns for landfill owners and operators, and are uniquely supported with a single piece of equipment and common materials. All necessary equipment is mounted on a skid that is placed in the bed of a pick up truck, and can be easily installed, or removed as needed. The skid is complete with mixing pumps, air compressor, and generator designed for remote operation. All that is needed is a source of water. Consumable materials are water-soluble and do not involve handling or storage of hazardous materials. The heart of the process is the kiln-dried plastic resin that comes as a water-soluble powder that is mixed just prior to use.

PolyMaster has developed what it believes is the ideal system for managing the most common environmental compliance issues shared by landfill operators today. With so many specialized applications in the marketplace, this system is unique because it provides solutions to so many problems with just one piece of equipment. The system provides for simple operation, and can be used by landfill personnel or environmental service providers as an effective tool for managing compliance.