IMPROVED GEOMEMBRANE DAMAGE/LEAK DETECTION THROUGH CO-EXTRUSION TECHNOLOGY

Daniel P. Messmer and Mark Cadwallader
Gundle Lining Systems
Houston, Texas

ABSTRACT

Co-extrusion technology which has made possible textured geomembrane and multi-colored layered liner is now used to add a thin electrically conductive layer to standard liners, using electrically conductive carbon black. The liner is installed with the electrically conductive layer on the bottom and non-conductive layers on the top. Standard spark test equipment may be employed to test the liner for leaks, inducing a charge in the conductive undersurface through a charged neoprene pad, and passing a conductive wand over the liner surface to detect holes which spark the charge across to the wand. The equipment provides output signals for an audible alarm. This signal is used to mark the exact location of the defect for repair. This paper will survey some of the new co-extruded synthetic liners, including the geomembranes 100% spark-testable after installation.

INTRODUCTION

There has been considerable advancement in technology available for providing a barrier system in the containment and storage of waste materials. Natural soil liners several feet in thickness have been replaced by factory-produced synthetic materials that have permeability coefficients several orders of magnitude lower than any natural soil system. To carry the systems approach one step farther, engineers use multiple layers of synthetics separated at times by layers of clay offering a redundant composite barrier to protect the groundwater. Each geosynthetic material offers its own unique contribution to the system based upon its physical characteristics. These physical characteristics are a result of the manufacturing process. Co-extrusion, the process of combining two or more materials into a single product through a single process has revolutionized the packaging industry. Applying these same techniques to the manufacturing of geomembranes or synthetic liners allows the production of a single barrier element with the attributes of each material combined during co-extrusion. The following sections will address the contribution that these new co-extruded products have made with particular emphasis in the areas of damage detection and leak prevention in linings for waste material storage.

CO-EXTRUSION

Most of the polymeric materials used in the waste industry are thermo-plastics polymers. In other words, the transition from one physical state to another is a function of the amount of heat applied. Through the manufacturing process, high density polyethylene (HDPE) is heated to its melting point as it passes along a heated extruding screw. The molten polyethylene is delivered to a die and forced into the air where it begins to solidify in its new shape. The innovative step in co-extrusion brings two or more molten streams of polyethylene together in the die before it exits and begins to cool. The individual layers of molten polyethylene join together at the molecular level while in their molten state. As a result the finished product is a uniform homogeneous material from top to bottom (see Fig. 1). Even in a product that has an additive package for coloring one or both outside surfaces, the base performance of the product is a function of the base polyethylene, and the values are not any different than those of a single layer extrusion.

The thicknesses of each layer can be varied according to the performance requirements for the finished product.

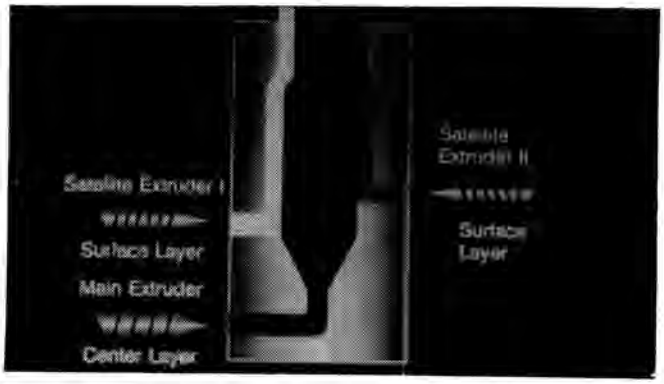

Fig. 1. Multi-layer coextrusion.

In addition to thickness controls on each layer, it is possible to augment the molten streams to produce physical differences in the manufactured product. By introducing a stream of nitrogen gas to the outside molten streams of polyethylene in the satellite extruders, a textured surface product can be produced. Like carbon dioxide escaping from a can of soda, the nitrogen escapes from the liquid polyethylene as it leaves the die. Since the polyethylene is beginning to cool, the pattern left behind by the escaping gas remains in the surface. This is a one step process to produce a liner that has an integral textured surface in a homogeneous media. Textured liner has been produced to overcome interface friction problems that occur between the different layers of material used in the design of containment facilities. By increasing resistance along critical design interfaces, the overall stability of the whole system may be greatly enhanced.

Some of the uses for co-extruded liners come as a result of the process's ability to produce membranes with two contrasting colors. Orange and white co-extruded liner for example has been installed as waterproofing of a highway tunnel liner (see Fig. 2). The material was installed so that the white surface faced the inside of the tunnel and the orange faced the newly cut rock face. The white reflected the electric lights strung out through the work area increasing visibility and subsequently safety. The orange surface provided a highly visible contrast on the white surface. When a small rock falls or other penetrating damage occurred, it could be easily spotted and repaired. The presence of a single product with two colors allowed for easier inspections and insured an integral barrier before placement of the concrete tunnel lining. Co-extrusion technology has made a significant contribution to safety and inspection efficiency in the construction of tunnels and other areas of civil engineering design.

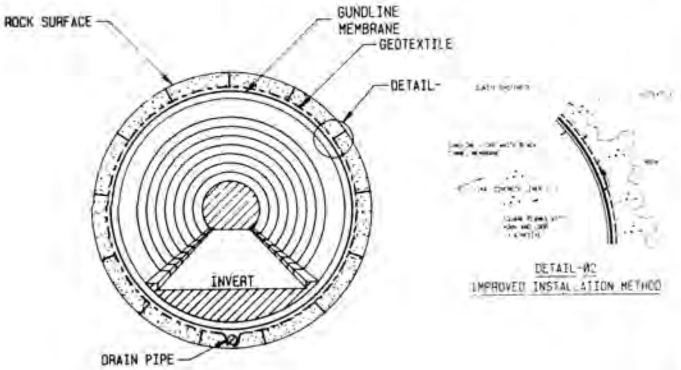

Fig. 2. Improved installation method.

TYPICAL TUNNEL - PRECAST SEGMENTAL

Damage Detection Plus

In landfills, the integrity of the flexible membrane liner or geomembrane is paramount. Specifications meticulously define the performance characteristics of the membrane to insure it will provide a barrier to the liquid contained in and resulting from the placement of waste materials stored above it. The specs also dictate the chemical resistance, strength requirements, and long-term weatherability for the geomembrane products to be used. The requirements for strength and chemical resistance are satisfied by the choice of base resin for the production of the liner. Weatherability has been insured by the addition of 2-3% of carbon black to the finished polyethylene sheet.

It is unfortunate that no matter how tightly controlled the basic properties of the membrane are, accidental damage and perforations resulting from construction operations still occur. In some cases, these small penetrations may go undetected since they can be very difficult to see on standard black shiny surfaces. But as with the two colored tunnel liner, using a contrasting foreground color greatly enhances visual inspections by providing a contrasting background to significant damages.

Co-extrusion technology allows production of Gundline HDW, a black and white liner. The white surface is approximately 5 mils thick and stabilized against ultraviolet light with a hindered amine light stabilizer. The bulk of the sheet is stabilized with 2 to 3% carbon black (see Fig. 3). The presence of the white surface does not affect the performance characteristics of the liner due to the homogeneous intermingling of the polyethylene melt during the production.

CO-EXTRUDED WHITE-SURFACED LINER

In the field, should a tool be dropped or the liner gouged by some other action, the black liner shows through the white surface. These highly visible marks can then be inspected and tested to see if they have penetrated the full thickness of the liner.

The added value obtained from utilizing such co-extruded products in a new landfill construction does not stop with an inspector's activities. The white surface also helps to protect the subgrade from the adverse effects of the sun's energy. The subgrade or soil component of a composite liner relies on the engineered balance of water and solids in its structure to provide a barrier to liquid migration. If heat is applied in sufficient quantities, the water vaporizes and leaves the soil. The now desiccated soil is no longer a barrier but a maze of cracks that allow liquid to move through the full thickness of the layer. Reducing the heat in the overlying geomembrane reduces or eliminates the loss of moisture from the soil. An effective means to reduce the heat is to cover the liner with soil. From recent tests, it is apparent that the white surfaced liner is equivalent to two feet of soil in reducing the deleterious effects of heat through a liner on the subgrade. (1)

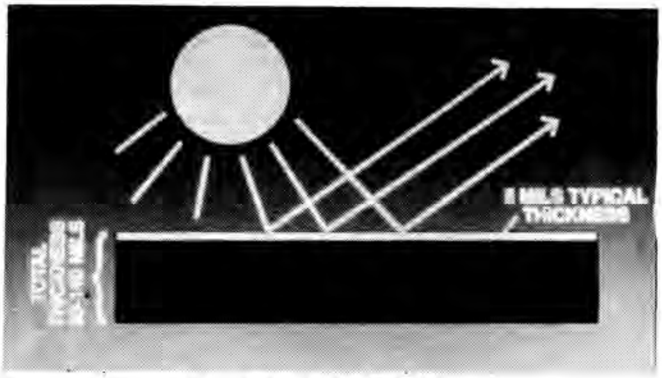

Fig. 3. Gundline® HDW.

Not only is the excessive heat generated in the liner by the sun a problem for the underlying soils, it can create havoc for installation. Thermal expansion and contraction in the liner material has a significant impact on construction. Excessive wrinkles due to thermal growth of the sheet slows the seaming process, cover soil placement, and when the sheet cools and shrinks, may bridge depressions causing uncalculated stresses.

"Intimate contact", the desired feature of composite liners, is disrupted by folds and wrinkles making it desirable to stabilize thermal expansion/contraction. A white surface absorbs less energy than it reflects, thereby decreasing the internal temperature of the sheet. There is then a corresponding reduction in expansion and contraction of the geomembrane allowing for a more efficient installation. The advantages to using a white surface, listed in the preceding sections, are numerous. Only with a single step, co-extrusion process is this advanced engineered product possible.

LEAK DETECTION

The principal motivation behind recent EPA revisions to Subtitle D regulations is to insure the protection of the groundwater table necessitating the use of composite lining systems. Following construction of these systems, waste is placed within the lined facility and begins to generate leachate. Leaks in the liner, if they exist at all, are most often detected after a load is placed on the system and a positive flow driven by gravity begins. Therefore a leak-free system is the goal for any and all landfill construction. A program designed to survey the bottom and side liners for leaks is a costly and painstaking endeavor. There are a wide variety of testing methods available and until now, no single style could claim to be 100% effective. The most commonly chosen method was flood testing. In this application, a power supply is connected to electrodes above and below a liner. The impoundment is flooded to a prescribed depth with a conducting media, most commonly fresh water. A uniform current will flow along the surface of the liner if there are no leaks. However, should there be a penetration in the membrane, a localized anomaly will develop in the distribution of the electrical field at the location of the leak, which is recorded and repaired once the cell is drained. A technician must probe the entire surface which means wading or searching by boat, depending on the configuration of the confinement. This survey technique is expensive, slow and requires a fair number of skilled technicians to perform. In addition, a second survey is usually required to determine if all the defects have been located and repaired. Leak detection methods that are in use today are useful. Unfortunately the cost and time spent conducting these surveys has limited their practicality to only the most critical containment facilities.

A new development for effective and efficient leak testing system would not have been possible without the advantage of co-extrusion technology. In the pipe industry, "holiday" or "spark" testing has been used to locate pin holes or thin spots in the various coating media applied. An electrode is attached to the inside of the pipe and a wand or brush, as shown in Fig. 4.

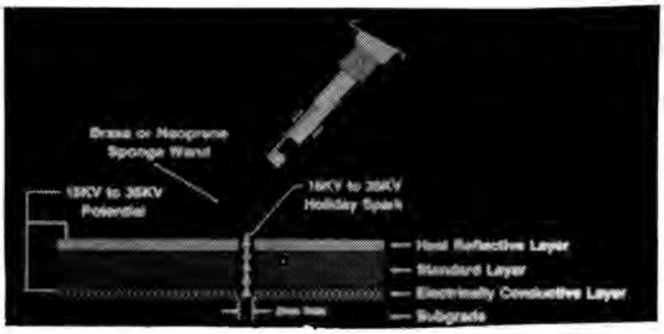

Fig. 4. Gundle high density conductive geomembrane with accompanying holiday spark testing equipment.

CO-EXTRUDED SPARK TESTABLE LINER

connected to the opposite terminal is passed over the coated surface. At a hole in the coating, a spark jumps to the wand, the location is marked, and a repair is made. In the lining industry, this same schematic was used for a number of years to check extrusion welds. A thin copper wire was embedded in the weld bead. A voltage source was connected to the wire and a brass brush was passed over the surface. Again, if a pin hole existed, there would be a spark to identify the area to be repaired.

It is now possible to use this simple technology to test every square inch of the liner installation without having to flood the constructed cell. Co-extrusion technology, which made it possible to produce textured liner and multi-colored products is used to add a thin electrically-conductive layer to our standard geomembranes. The layer is approximately 5 mils thick and has a high concentration of high purity carbon black, making it electrically conductive.

PROJECT APPLICATIONS

In a recently constructed project at a large copper mining facility, co-extruded white-surfaced conductive liner was used to construct a stormwater and process water containment pond. The specifications called for a double lined system with a drainage layer for leak detection between the two lining layers. The use of a white-surfaced primary liner reflected the sun's energy creating stable liner temperatures that improved seaming operations, as well as enhancing visual inspection of the liner surface for gouges or construction damage. The conductive layer allowed both the primary and secondary liner to be spark tested with 100% reliability.

Once the liner was deployed and seamed, it was ready to be spark tested. To do so, Gundle Lining Construction Company used a 750 pound (340 kg) six-tired All-Terrain Vehicle (ATV) which pulled a spark testing unit mounted on a trailer (See Fig. 5).

Fig. 5. Vehicular spark testing unit in operation.

The spark testing unit consisted of a 30,000 volt battery charging a sliding neoprene contact pad, and a six foot (1.8m) wide brass brush testing a six foot wide strip of liner as the ATV moved forward at two to three miles per hour. In this way, the entire lined area was "mowed" making sure that all leaks were detected and repaired.

To induce a charge in the conductive underside of the liner, the neoprene pad connected to the battery was mounted on the vehicular test unit, contacting the liner directly ahead of the brash brush. The neoprene pad, being electrically conductive, brings the voltage to the surface of the sheet and induces an electrical charge in the conductive underside of the liner through electromagnetic induction. As the brass brush moved over a leak or penetration, the charge transmitted through from the conductive underside of Gundline HDC to the brush, completing the circuit, creating a spark, and setting off an alarm. The charged neoprene pad slides along the membrane as the vehicle moves forward, so that it is always in close proximity to the brass brush.

One Gundle technician operated the vehicular-mounted test unit and a 3rd Party Inspector from S. H. & B. Agra of Reno, Nevada walked behind the unit as it tested the liner for leaks. When a leak was found, the unit was stopped and a small hand-held wand was attached to the battery to verify the leak location which was then marked by the inspector as to whether he felt an extrusion weld bead or an oval-shaped patch should be placed over the hole. Both methods of repair were used depending on the size of the damage.

The owner's project personnel purposely created small holes, the location of which was recorded by the inspection firm, to check the reliability of the spark testing method. All such purposely created holes were detected, although their location was completely unknown to Gundle personnel.

CONCLUSION

Co-extrusion technology gives engineers the added flexibility of a diverse range of products to meet the challenges of their lining projects. In addition these new products can be effectively and efficiently installed and tested in the field to meet the tight requirements of project specifications. The end result line is a completed project constructed with products guaranteed to improve the detection of damage and the prevention of leaks in addition to improved construction of liners and composite liners, protecting the groundwater from contamination.

REFERENCES

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