FEATURE ARTICLE

Clive Mills, *Western Nonwovens, Inc.*

How Do Your Bunkers Liner Up?

Bunker liners have been used increasingly in new construction and remediation projects for approximately five years, although the background geotechnical engineering and geosynthetics knowledge has been in use for decades in more traditional civil engineering applications (e.g., road construction, shoreline protection, etc.). The benefits to the golf course in using bunker liners are: dramatically reduced bunker sand washouts due to rain and reductions in labor expenses for associated sand repairs. Bunker liners have been shown to prevent contamination of bunker sands and improve the overall aesthetics, playability, and consistency of the bunkers on the course.

Technical Performance

In the context of this article, a 'bunker liner' is actually a relatively thick and highly permeable geotextile-like product specifically intended to drain and stabilize bunker sand. Bunker liners typically vary in thickness from ½" to ¾" or more. Thicker, higher drainage capacity products are often selected for steeper flashings or for more critical bunkers while thinner, lower drainage capacity products may be used for flatter areas or where drainage demands are less critical. Most products are made of polyester or other durable synthetic fibers, bonded together by synthetic, non-water-soluble resins. These products are substantially different from the more traditional, much thinner, needlepunched, non-woven geotextile products used in civil engineering applications. Traditional geotextiles have been used in the past in bunker applications but with mixed to poor results. Today's commercially available bunker liner products (e.g., SandMat, Sandtrapper, and Sand daM) all vary somewhat in their appearance and width but all have demonstrated an ability to function successfully for their intended purpose (i.e., sand stabilization, subgrade separation, filtration and drainage).

In the intended application, the bunker liner is designed to relieve the bunker sand of potential excess pore water pressure build up and to transfer the water as quickly as possible to the bunker underdrain system. It is not the role of a bunker liner to replace an adequate underdrain system. Without an adequate underdrain, the water will still stay in the bunker! By rapidly removing water from the sand, sand saturation and build up of pore water pressure is prevented and the sand retains its natural stability (governed by its internal angle of friction, or repose, which is dictated by such factors as grain size distribution and angularity, etc.).

The key to long-term performance of a bunker liner performing in a drainage capacity is ensuring that, long-term, the permeability of the geosynthetic bunker liner always exceeds that of the overlying bunker sand. For example; although reasonably well suited for many drainage applications, traditional needlepunched geotextiles do not possess sufficient permeability to perform long-term in this application considering the various factors that can reduce performance (i.e., such factors as soil clogging, chemical clogging, biological clogging, soil intrusion and creep).

Product Selection

A review of the literature on the subject of recommended bunker sand permeability, 'k,' (properly called *hydraulic conductivity*, but also called 'infiltration rate') suggests consideration of bunker sands with a minimum value of "20 inches per hour"

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(0.014 cm/sec) ? although initial values may be as high as "50 inches per hour" (0.035 cm/sec) (Moore, J.F. "How to select the best sand for your bunkers," *USGA Green Section Record*, January, 1998). Recognizing that geosynthetics are susceptible to long-term performance reductions due to the factors indicated above (which when summed can produce a total reduction factor in the realm of two orders of magnitude vs. initial specification values), it is important to select a product that offers sufficient drainage capacity, that when performance is reduced by these factors, still provides a suitable factor of safety compared to the permeability of the sand. Bunker liners often require initial permeabilities in the range of 5,000 inches per hour (3.5 cm/sec) to 8,000 inches per hour (6.0 cm/sec) in order to ensure adequate drainage capacity long term.

The decision on which bunker liner to use is usually a complex one often involving the clubs greens committee, possibly an architect, possibly a contractor, and, hopefully always, the input of the golf course superintendent. Larger remediations usually involve architects and many architectural firms are now quite familiar with bunker liner usage and installation. Factors that come into play are materials cost, installation cost (usually driven by roll width, with wider roll materials usually being the most effective due to reduced factors for overlap and waste, plus faster coverage), availability of a warranty, and proven performance for the intended purpose.

Installation Considerations

Installation of bunker liners is a fairly simple, yet often labor intensive, operation usually involving such high-tech equipment as steel staples, heavy duty scissors and rubber mallets. The product itself is shipped to site in plastic-wrapped or bagged rolls (roll widths vary from about 6 feet to 10 feet depending on the manufacturer). In new construction the liners are placed over the prepared subgrade after the drainage lines have been placed. The rolls are deployed, overlapped, stapled or staked to the ground and trimmed to the desired outline. Bunker sand is then added. In a bunker remediation, the existing bunker sand is removed prior to installation of the liner.

One of the first questions that should be asked is "what kind of subgrade soils exist on the golf course?" In the coastal areas of the southern United States and throughout much of the Caribbean for example the soils tend to be highly saline and fairly corrosive. Very 'fat' heavy clays can also be quite corrosive. Corrosivity of the subgrade soils can have an impact on the selection of the soil fasteners used to fix the bunker liner to the soil. Corrosion of the soil fasteners (the staples) can have an effect on the long term performance and effectiveness of the liner. The dead weight of the bunker sand is not itself enough to hold the bunker liner in place. If insufficiently fixed to the ground, foot traffic and the action of mechanical raking can result in the bunker liner tending to 'float' up into the bunker sand.

If the staples corrode badly enough there is essentially nothing holding the bunker liner in place. On steeply flashed bunker areas the soil fasteners are needed to adequately fix the liner to the subgrade and successfully transfer shearing forces caused by frictional effects of the sand with the liner into the subgrade material. Improper soil fastener selection can have severe implications for the stability of the bunker liner and the overlying bunker sand. On steep, flashings staples are usually placed on 6" to 8" spacings. On flatter floor areas, spacings on staples can be opened up to 12" or more depending on the firmness of the subgrade soils. On average, you should allow between 1.5 and 2.0 staples per square foot of bunker liner.

Absolutely avoid use of 'sod staples' for fixing the bunker liner to the subgrade. Sod staples will corrode and potentially impact the liner's performance. For most soils, use of corrosion resistant, bezinal-coated steel staples is adequate. The length of the staple is usually 6" to 8". Longer staples may be required in very sandy conditions (use of 12" 'washered pins' to hold the liner down is not unheard of). For very corrosive soils the use of plastic stakes is highly recommended. At least one bunker liner manufacturer now offers heavy duty plastic staking for corrosive environments.

Although bunker liners can contribute to improved drainage and bunker sand consistency throughout the entire bunker, very often, for economic reasons, bunker liners are placed only on the sloped faces of the bunker. In these cases the bunker liner should be terminated within the bunker by folding or running the liner into the gravel drain line at the toe of the slope. Otherwise the liner can usually be extended over top the gravel trenches.

Aesthetics and Maintenance Issues

The next major question to be asked is "how are the edges of the bunkers to be maintained?" This is usually a thorny issue since it speaks to the 'architectural appearance' of the bunkers, which may be somewhat in conflict with the desired lowest cost maintenance practices available. How the edges are to be maintained directly effects the installation of the bunker liner, specifically as to how it is to be terminated around the bunker perimeter.

If the surrounding turf is to be allowed to 'droop' over the edge of the bunkers (with maintenance usually involving a wire trimmer, 'weed whacker,' or similar treatment) then the bunker liner can often be terminated directly below the turf so that exposed edges of the liner are covered over by the 'drooping' turf. Stapling or staking can be accomplished around the perimeter by stapling or staking horizontally back into the perimeter soils (with the liner terminated vertically around the lip in this case).

In some existing course remediations, and depending on the turf type, it is common practice to trim away 12" to 18" of turf from the perimeter and run the bunker liner up over the lips and out to the trimmed distance, stapling or staking vertically down through the liner into the exposed soil (with the liner terminated horizontally around the perimeter). The trimmed turf is then placed back, directly over the liner, possibly with some top soil added first. Again, this practice depends on the turf type.

If neatly trimmed and exposed soil lips are to be the expected norm then the bunker liner needs to be terminated low enough so that edging equipment does not cut the liner or hit buried staples. Terminating the bunker liner horizontally at the base of the vertical sand shelf effectively reduces the risk of cutting the liner. However, in certain soil types, leaving the vertical sand shelf or lip area unlined can contribute to contamination of the bunker sand due to soils bleeding laterally into the sand. It is also common practice to cut a slot (e.g., with a spade) into the subgrade soils on the slopes and wedge the liner back into the soil. This can be tedious work but does help anchor the liner and prevent any loose edges from becoming further exposed or snagged.

Other Considerations

An issue that has literally surfaced with bunker liners, particularly in northern climates, is frost heaving of the staples up into the bunker sand or turf. Frost heave can only occur if there is a frost susceptible soil (e.g., silty soil), water, and freezing temperatures. Although some research is being conducted into this phenomenon, if the soils on the course are highly frost susceptible, over excavation of the bunker subgrade soils and replacement with clean granular fill is likely the best solution. Obviously the added cost of this activity would need to be weighed against the benefit of the liner on the course's future maintenance budget and desires for improved bunker sand aesthetics and playability.

The decision on which bunker liner to use is usually a complex one often involving the clubs greens committee, possibly an architect, possibly a contractor, and, hopefully always, the input of the golf course superintendent.

The largest concern cited for bunker liners is snagging of the liner by mechanical raking equipment and the need for increased hand raking. If proper staple or stake selection is made in consideration of the potential for corrosion, and if stapling or staking is done properly with the right staples and in the proper quantity, then 'floating' of the bunker liner and snagging on rakes should be easily avoidable. Regular checking of the bunker sand depth to ensure at least 4" sand cover is always recommended.

There is a growing trend towards use of recycled waters for irrigation. Typically recycled irrigation water is also quite saline. If the golf course is using or going to be using recycled water for irrigation, the impact of the resulting salinity on the bunker liner soil fasteners should also be taken into consideration. Use of plastic stakes is usually recommended in these cases. **-OC**

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TECHNICALLY SPEAKING WITH TETA

TETA Meets at the Turf Professionals Equipment Company's New Location

Members of TETA met at TPEC's new Franklin Park Location in May. Jim Shone and Kevin Humke of Spraying Systems provided the education for the day. They went over the latest advancements in spray nozzle selection, followed by live demonstrations of GPS (global positioning system) enabled spray control. Many technicians were present to learn about these processes and more. Thank you to our presenters, Jim Shone, Kevin Humke, and Ivan Brown. A special thank you goes to Mike Murphy and TPEC for providing the space for the meeting and a fantastic lunch for everyone present. **-OC**

Members of TETA spent the morning listening to Kevin Humke and Jim Shone of TeeJet and learning about spray technology.

Who says nozzle selection is not important?
Notice the coarse droplets on the left compared to the finer spray droplets on the right.

TECHNICALLY SPEAKING WITH TETA

Stephen Spuhler, *Merril Hills Country Club*

John Deere Horicon Works

Nestled in a farming community of 3700 in South-Central Wisconsin lies one of the major underpinnings of John Deere's Golf & Turf division. Encompassing 214 acres and employing up to 1700 people, John Deere Horicon Works has a long and rich history of providing equipment for the residential and commercial consumer, for agriculture, and for the golf & turf industry.

A grain drill company owned by George and Daniel Van Brunt and built in the early 1860s, was bought by John Deere in 1911. In 1958, the name was changed to John Deere Horicon Works. In 1963, the first lawn tractor rolled off the assembly line. Recently, they passed the five million mark for lawn tractor production. From 1971 to 1984 snowmobiles were made at Horicon; that segment was then sold to Polaris. In the late 1980s, the facility came under the umbrella of the Commercial and Consumer Equipment division, where it remains today. In 1991, the "Reel Cell" was created, consolidating the manufacturing and assembly of all reels, reel cutting units, and the green and tee walkers.

I had the chance to tour the facility with my host Dick Thier from Engineering and with Jerry Hagen, who recently retired after 32 years at Horicon. Jerry probably gives the tours because he's one of the few around who knows every square inch of the 214 acres, as well as what went on in every nook and cranny of the facility for the last 32 years. Today was a "slow" day by their standards; the busy time usually runs from January to July.

The Reel Cell

As a separate area of the plant created in 1991, the first reel was made in late '91-early '92. The only thing on the reel itself that is outsourced is the center shaft. The machining of the center shaft ends, stamping of the spiders, and the reel blades themselves are all done in-house; as well as the robotic welding and heat treating of the reels. The welded and cast bedbars are machined by an outside supplier, but the bedknife/bedbar assemblies are finish ground here. The rollers are done in-house. The 18, 22, and 26 inch walkers are completely assembled here, as well as all the cutting units for the triplex and fairway mowers. The reels and bedknives are both ground prior to cutting unit assembly. The cutting units are then shipped to JD Turf Care in Fuquay-Varina, North Carolina, to be shipped with the traction units made there.

Paint

They use an electrostatic powder paint process which includes a "dip" or submersion in a bath. I was happy to see that. After working on various makes of equipment over the years, I found "if you just spray and bake; it's going to flake." Eventually, the paint comes off a cutting unit or deck in sheets. The submersion bath is the key. They've got nine miles of overhead track carrying parts on racks through the painting process, which takes eight hours from start to finish. For the hard to reach places on some parts, a robot is used to spray those areas. The robot is programmed for the specific part that's in front of it.

A Pressing Matter

Or as the rock group Queen would say..."Under pressure." Besides making all the decks for the lawn tractors, all the 7 IronII™ decks for Commercial and G&T are made here. The "7" refers to the 7 gauge steel used in the deck; it's the thickest currently being used by the Big Three for rotary decks. These decks are pressed out in one piece. The only welds are made for brackets for the anti-scalp rollers on the outside and the baffle chamber on the inside. It's a safe bet that they have the biggest, baddest press in the golf industry. It stands three stories tall and has 2000 ton capacity. That's four million pounds of force. And you might want to schedule your vacation for when you change the hydraulic fluid; the hydraulic tank holds 4000 gallons.

On The Line

Besides the reels, cutting units, and walkers, the X300, X500, and X700 series tractors for the consumer market are also made here; as well as the compact and heavy duty Gator™ Utility Vehicles with gas and diesel engines. Even though they may be the "new kid on the block" in the golf industry, their 100+

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years experience with manufacturing is very evident. They have AGVs and AGCs (auto-guided vehicles and carts) that roam the facility. AGVs have been in the auto industry for quite a while, but in my visits to three different manufacturing plants in the golf industry, this is the first time I've seen them used. The AGVs are all-electric and follow a wire buried in the floor. They pull up to a conveyor belt loaded with pallets of parts, the conveyor loads the pallet onto the AGV, and it takes off on it's merry way, headed to the station on the line where the parts will be used. I watched one pull up to a conveyor, get its parts, get on an elevator, go down one level, and head off to a station on a line there. If they have no further job assignments, they head back to their staging area or "corral" to await further instructions or get plugged in for a recharge. There are still forklifts, just a lot fewer of them. The main aisles are as wide as they were before in order to handle any forklift traffic; but these auto-guided things run next to the aisle like in a "carpool" lane. As one line was getting ready to start, I saw a whole bunch of the AGCs appear out of nowhere; lining up with the same distance between them and each carrying a complete rear end assembly; all headed to the same station on the line. The first time you see these things; you just stop and stare.

Each station on the line has a 19" LCD screen, which shows the assembly area for that station, lists the part numbers, their location, and the assembly sequence if needed. Those stations that perform multiple tasks have touch-screen capability to change menus.

All the air ratchets are calibrated to a specified torque; some stations can have six to eight of them hanging down. In each airline for each ratchet there is an electro/pneumatic sensor that detects how many times the ratchet was used, if at all. If something doesn't match up with the number of ratchets used or the number of times a specific one was used, the station automatically locks itself down and the unit being assembled cannot move forward to the next station until the problem is corrected.

As one line was getting ready to start, I saw a whole bunch of AGCs appear out of nowhere...

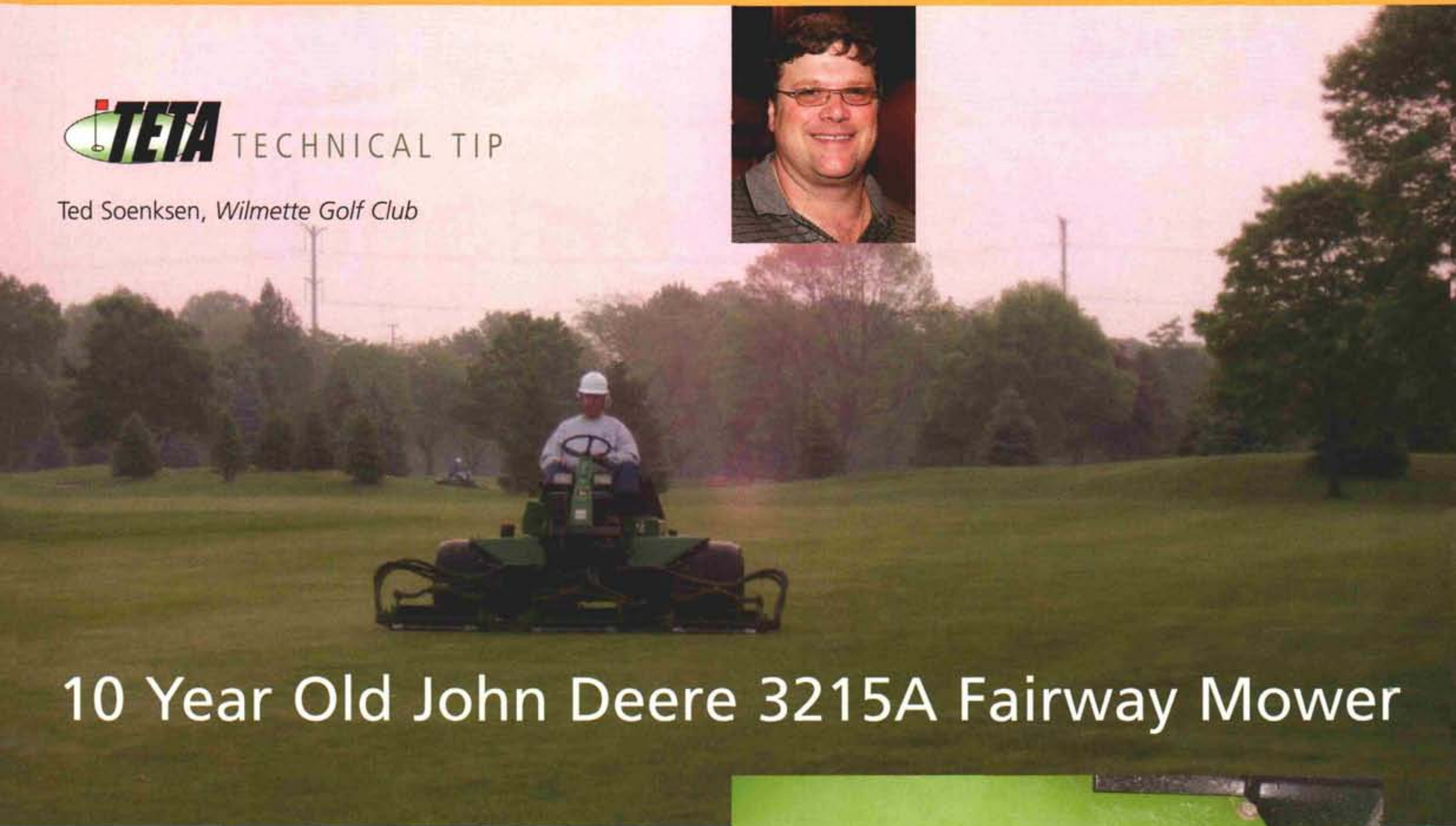
All engines, both gas and diesel, are run and tested on the line to make sure everything is working OK. Diesels are left with about a gallon in the tank so they don't have to be bled after purchase. For the gas engines an auxiliary fuel line is hooked up directly to the carburetor for starting. Jerry says they use a type of aviation gas in the engines so that when the fuel line is disconnected and the engine runs until it dies, any residual aviation fuel in the carburetor evaporates quickly and leaves no deposits.

Just in Time

John Deere and many others in the business of manufacturing products use the "Just in Time" model for stocking parts and making them available to the assembly lines. It is what it says. Parts arrive from vendors just in time to be used, usually a few days in advance. This eliminates not only the need for a massive warehouse and its associated maintenance costs, but also the need for excessive inventory that's just sitting around off the books.

The Horicon Works really knows how to put this model to the test. Remember I said this was a slow day? Jerry showed me one assembly line where they have the capability when fully manned to turn out over 400 lawn tractors per shift...about one every minute. There are lines making other tractors, Gators, cutting units, walkers and reels at the same time. In the photo you can see a bridge across some water and a road cutting through the facility. That road is the town's Main Street. To eliminate the problems of dealing with traffic and the weather (we do have winter in Wisconsin) they have a tunnel running underneath Main Street, so they can shuttle parts and product back and forth seamlessly. It takes a well-coordinated effort to keep the parts moving.

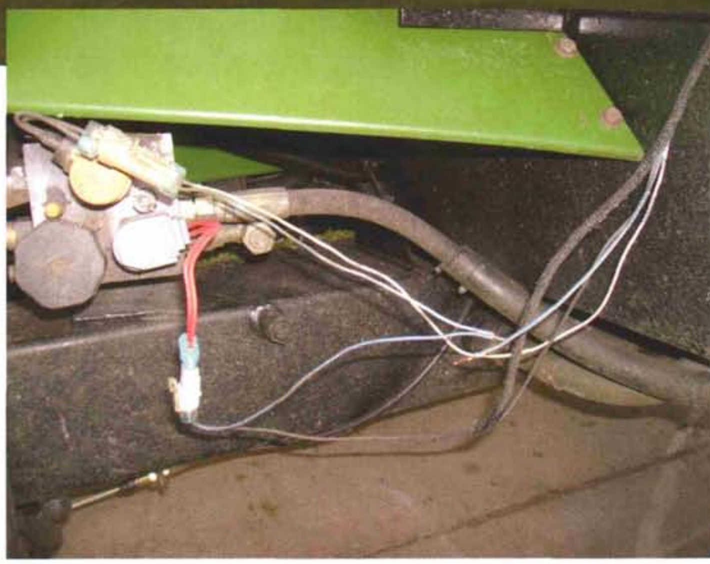
They may be the new kid on the block, but they've grown up quickly. **-OC**



TETA TECHNICAL TIP

Ted Soenksen, *Wilmette Golf Club*

10 Year Old John Deere 3215A Fairway Mower



Problem:

Operator stipulates the rear cutting units do not come on consistently. Once they are "on" and cutting they stay "on." Next swath cutting units may or may not come "on."

Solution:

After inspecting the wiring around the rear mow valve, I found a break in the power supplied to the solenoid. Upon further inspection, I discovered the wiring was faulty where the wiring harness was zip-tied to the adjacent hydraulic hose, (see image: blue wire being split to supply both solenoids). After stripping back the insulation and the rubber sealed shrink-wrap, I found that corrosion from 10 years of moisture was trapped in this area. The actual break was pinpointed at the factory spliced connection that supplies voltage to both the mow solenoid and the back lap circuit.

Repair:

Simply, properly splice the wire and protect it with weatherproof connectors and seal with fusion tape.

Tools used:

Volt/ohm meter, a utility knife, John Deere technical manual, wire strippers.

Labor:

Clean machine before inspection	15 minutes
Diagnosis (with volt/ohm meter)	5 minutes
Repair time	10 minutes
Down time total	**30 minutes**

Ted Soenksen
Equipment Technician-Wilmette Golf Club
President TETA

Have you figured out a better way to do things? Have you found an answer to a chronic problem on a specific piece of equipment? Have you developed, modified, or created a tool to make your job easier? If so, share your knowledge. Send technical tips to *On Course,* please email them to luke@magcs.org. If you are able, send photos as well.