

S T A T E

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T E N N E S S E E

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SPECIAL PROVISION
REGARDING
PREFABRICATED VERTICAL DRAINS

627.01 Description – The work shall consist of furnishing all necessary labor, equipment, materials, incidentals and transportation for the installation of Prefabricated Vertical Drains (PVDs) in accordance with the details shown on the Plans and the requirements of these Specifications.

627.02 Testing Standards – Use the latest edition of the testing standards indicated in this Special Provision. Substitution of standards will require the prior written approval of the Engineer. The Contractor or the PVD Installer is to provide copies of all substituted standards to the Engineer.

The most recent version of the following testing method(s) may be employed:

- Abrasion Resistance of Textile Fabrics (Rotary Platform, Double-Head Method); ASTM D3884
- Grab Breaking Load and Elongation of Geotextiles; ASTM D4632
- Trapezoid Tearing Strength of Geotextiles; ASTM D4533
- Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products; ASTM D4833
- Mullen Burst Test; ASTM 3786
- Water Permeability of Geotextiles by Permittivity; ASTM D4491
- Apparent Opening Size of a Geotextile; ASTM D4751
- Tensile Properties of Geotextiles by the Wide-Width Strip Method; ASTM D4595
- (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head; ASTM D4716
- Particle-Size Analysis of Soils; ASTM D422

627.03 Materials - The PVDs shall consist of newly manufactured materials and shall consist of a continuous polymeric drainage core and nonwoven geotextile filter fabric (jacket). The jacket shall allow

free passage of pore water to the core without loss of soil material or piping. The core shall provide continuous vertical drainage. The core and jacket material may be either non-bonded or bonded. For non-bonded PVDs, the jacket material is wrapped around the core and seamed to itself. For bonded PVDs, the jacket material is fused to both faces of the core along the peaks of the corrugations.

JACKET MATERIALS – The jacket components shall conform to the following:

- The jacket material shall be a synthetic nonwoven polymeric geotextile meeting the criteria listed in Table 1.
- The jacket material shall not be subject to localized damage (e.g., punching through the filter fabric by sand/gravel particles).
- The jacket material shall be rigid enough to withstand lateral earth pressures due to embedment and surcharge so that the vertical flow capacity through the core will not be adversely affected.
- The jacket material shall be flexible enough to bend smoothly during installation and during any induced consolidation settlement without damage.
- The jacket material shall not undergo cracking and peeling during installation of the vertical drain.

Table 1 – Jacket Material Properties

PROPERTY¹	TEST METHODS	UNITS	REQUIREMENTS
Mass	ASTM D5261	oz./yd ²	≥ 4.0
Grab Elongation	ASTM D4632	%	≥ 50
Grab Strength ²	ASTM D4632	lbs.	≥ 130
Tear Strength ³	ASTM D4533	lbs.	≥ 60
Permittivity	ASTM D4491	sec. ⁻¹	≥ 0.5
AOS	ASTM D4751	Sieve Size (mm)	#100 (≤ 0.15)
Ultraviolet Stability (Retained Strength)	ASTM D4355	%	≥ 50 after 500 hrs. of exposure

Notes:

¹All numeric values represent Minimum Average Roll Value (MARV) in the weaker principal direction. Provide geotextiles whose average test results from any roll sampled in a lot for conformance or quality assurance testing meets or exceeds minimum values provided in this Table.

²For bonded drains, grab tensile strength tests shall be conducted on the assembled drain using ASTM D4595.

³For bonded drains the trapezoidal tear strength test shall be waived.

CORE MATERIALS – The core materials shall conform to the following:

- The core material shall be continuous polymeric material fabricated with grooves to promote drainage along the axis of the vertical drain. Studded cores are not allowed.
- The core material shall meet the criteria listed in Table 2.

Table 2 – Core Material Properties

PROPERTY	TEST METHODS	UNITS	REQUIREMENTS
Thickness	ASTM D5199	in.	0.09375 (3/32)
Mass	ASTM D3776	oz./ft.	≥ 0.60
Tensile Strength	ASTM D638	lbs.	300
Crush Strength	ASTM D1621	psi	450
Ultraviolet Stability (Retained Strength)	ASTM D4355	%	≥ 50 after 500 hrs. of exposure

ASSEMBLED PVD – The assembled PVD shall conform to the following:

- The mechanical properties (strength and modulus) of the assembled drain shall equal those specified for the component jacket and core.
- The assembled PVDs shall be resistant against wet rot, mildew, bacterial action, insects, dissolved salts, acids, alkalis, solvents, and other components in the site ground water.
- Use only one single type of assembled PVD on the project.
- Provide an assembled PVD that meets the properties indicated in Table 3

Table 3 – Assembled PVD Properties

PROPERTY	TEST METHODS	UNITS	REQUIREMENTS
Perimeter	--	in.	≥ 7.75
Width	Measure with caliper	in.	≥ 3.75
Thickness	ASTM D5199	in.	≥ 0.1250 (1/8)
Discharge Capacity	ASTM D4716	gpm	1.5 (at 50 psi)
	ASTM D6918		1.5 (at 25% compression)

TRANSPORTATION AND STORAGE OF ASSEMBLED PVD – The transportation and storage of the assembled PVD shall conform to the following:

- Label or tag the assembled PVDs in such a manner that the information for sample identification and other quality control purposes can be read from the label. As a minimum, identify each roll of assembled PVD by the manufacturer as to lot or control numbers, individual roll number, date of manufacture, manufacturer and product identification of the jacket and core.
- During shipment and storage, wrap the PVDs in burlap or similar heavy duty protective covering. Protect the PVDs from sunlight, mud, dirt, dust, debris, and other detrimental substances during shipping and on-site storage. The PVDs shall be free of defects, rips, holes, and/or flaws. Material which is damaged during shipment, unloading, storage, or handling, or which does not meet the requirements of the drain material will be rejected by the Engineer.

SPLICING PVD

- Non-bonded PVDs may be field spliced. Remove approximately 6 inches of the jacket material from the current assembled PVD roll exposing the core. Insert the exposed core into the new roll of assembled PVD and secure using methods approved by the PVD supplier and accepted by the Engineer. The core material shall not be exposed after splicing. The core materials from each roll should be in firm contact with the corrugated peaks of one core overlapping the corrugated valleys of the other core.
- For bonded PVDs, provide to the Engineer the PVD Manufacturer’s splicing procedure for review and acceptance by the Engineer prior to any PVD material being installed.

PVD DRAINAGE LAYER – Unless otherwise stated in the Plans, the PVD drainage layer shall conform to the following:

- Place a drainage layer consisting of at least 24 inches, unless otherwise specified in the plans, prior to PVD installation.
- Unless otherwise specified in the plans, the drainage layer material shall conform to the following gradation requirements (ASTM D422), as shown in Table 4:

Table 4 – Drainage Layer Gradation

SIEVE	PERCENT PASSING
2-inch	100
½-inch	65-100
¼-inch	50-100
No. 10	40-70
No. 40	10-40
No. 200	0-5

- Material not meeting the gradation defined above will be rejected. Acceptance of materials will be at the project site.

627.04 Submittals – At least 30 calendar days before the beginning of the PVD installation, the Contractor shall submit to the Engineer for review, full details of the materials, equipment, sequence and method of installation. Review by the Engineer of these items shall not relieve the Contractor of the responsibility to install PVDs in accordance with this Special Provision. As a minimum, the submittal shall contain the following:

PREFABRICATED VERTICAL DRAIN MATERIAL - Acceptance of the sample PVD material by the Engineer will be required prior to delivery of the PVD material to the Project. At least 30 calendar days before beginning PVD installation, the Contractor and PVD Installer shall:

- Identify the proposed source of the assembled PVDs prior to delivery to the site.
- Supply, to the Engineer, a manufacturer’s material certification that the assembled PVD meets or exceeds the material requirements of this specification. The manufacturer’s literature shall document the physical and mechanical properties of the PVD. The PVD Manufacturer shall be a specialist in the manufacture of PVDs and shall have produced a minimum of 5,000,000 linear feet of the PVD material similar to that proposed for the Project and that has been successfully used in similar applications within the past 5 years, including details on prior performance on these projects.
- Submit to the Engineer, for review and visual inspection, 3 samples of the un-spliced PVD to be used and 3 samples of proposed splices, if splices are allowed on the project. The samples of un-spliced PVD shall be at least 5 feet long. Samples of spliced PVD shall be long enough to include the splice plus 2 feet of un-spliced drain on both sides of the splice. The samples shall be stamped or labeled by the manufacturer as being representative of the PVD material having its specified trade name.
- Submit to the Engineer, for review and visual inspection, 3 samples of the proposed anchor plate to be used to anchor the PVDs at the design depth shown on the plans.

PREFABRICATED VERTICAL DRAIN INSTALLER - Provide proof to the Engineer of the experience of the PVD Installer for the work described at least 30 calendar days prior to PVD installation. The PVD Installer shall:

- Document successful installation of at least 5,000,000 linear feet of PVDs during the last 5 years and shall be a certified installer of the PVD Manufacturer.
- Document at least 5 successfully completed projects within the last 5 years of similar size and complexity to that of the Project. Document the PVD Installer’s experience by providing a project summary that includes for each referenced project, the project start and completion dates, total quantity of PVDs installed, and a detailed description of the project, site conditions,

and subsurface conditions. Include in the project description details of the PVD materials, the equipment and technique used to install the PVDs, the average and maximum length of PVD installed, the client name and address, the name and telephone number of the representative of the consultant and owner for whom the work was performed and who can attest to the successful completion of the work, and any other information relevant to demonstrating the PVD Installer's qualifications.

- Identify a full-time supervisor who has been in responsible charge of supervising PVD installation operations for at least 5 projects in the last 5 years. The supervisor shall be present at the work site at all times during PVD installation operations. Provide a detailed resume of the supervisor's experience and qualifications. Provide a detailed resume for the replacement supervisor, if required.

PREFABRICATED VERTICAL DRAIN INSTALLATION PLAN - At least 30 calendar days prior to PVD installation, the Contractor shall submit to the Engineer, for review, a PVD Installation Plan that includes as a minimum the following information:

- The configuration of the installation equipment including size, type, weight, maximum pushing force, and vibratory hammer rated energy.
- Dimensions and length of the mandrel.
- Details of the PVD anchorage.
- Detailed description of proposed installation procedures.
- Proposed methods for securing splices in non-bonded PVDs or the manufacturers splicing procedure for bonded PVDs, if splicing is allowed.
- Proposed methods and equipment for pre-augering or spudding.
- Submit documentation of the successful application of the proposed PVD installation operations.
- Provide shop drawings showing the planned locations and bottom elevations of all PVDs, a unique identification number for each PVD, the proposed installation sequence, the location of all potential conflicts with the locations of the PVDs.

627.05 Submittal Reviews – Acceptance of the proposed materials, equipment, construction sequence, and installation method will be accepted by the Engineer. Acceptance of the PVD materials, equipment, construction sequence, or installation method does not relieve the Contractor and PVD Installer of its responsibility to install the PVDs in accordance with the plans and specifications. Acceptance by the Engineer of the method and equipment to be used to install the PVDs is contingent upon satisfactory demonstration of PVD installation at the project site. If, at any time, the Engineer

considers that the method of installation does not produce satisfactory PVDs, alter the method and/or equipment as necessary to comply with this Special Provision. The Engineer will determine the adequacy of the Contractor's methods and equipment.

627.06 Installation Requirements

- Install PVDs as indicated on the plans or as directed by the Engineer. Install the PVDs with equipment that will minimize the disturbance of the subsoil during the installation operation and maintain the mandrel in a vertical position. Size the equipment to minimize the disturbance of the subsoil during the installation operation. Provide equipment with sufficient push force to install the PVDs through all existing subsurface material to the depths shown on the plans. Size the equipment to have the capability of installing the PVDs to a depth of approximately 20 feet greater than the maximum PVD depth shown on the plans. Select equipment such that it will not force the fill soil into the existing soil, nor disturb the fill soil, nor cause any bearing capacity problems with the subgrade soils due to the weight of the equipment.
- Install the PVDs using a mandrel or sleeve that can be advanced through the soils to the required depth. The mandrel or sleeve shall protect the PVD material from tears, cuts, and abrasion during installation and shall be retracted after each PVD is installed. To minimize disturbance of the subsoil, the mandrel or sleeve shall have a maximum cross-sectional area of 10 square inches. The mandrel or sleeve shall be sufficiently stiff to prevent wobble or deflection during installation. In no case will alternative raising and lowering of the mandrel during advancement be permitted. Permit the raising of the mandrel only after completion of the PVD installation to the bottom PVD elevation shown on the plans or otherwise authorized by the Engineer.
- Install the PVDs using either a constant load or constant rate of advancement technique. Use a vibrator only when approved by the Engineer in areas where constant load or constant rate of advancement methods cannot install the PVDs to the design depths. Jetting or use of an impact hammer will not be allowed to install PVDs.
- Provide each PVD with an "anchor" plate or similar arrangement to anchor the bottom of the drain at the required depth during mandrel removal and to prevent soil from entering the bottom of the mandrel during PVD installation. The anchorage shall be adequate to keep the bottom of the PVD at the required depth subject to approval and field verification by the Engineer. The corresponding dimension of the anchor shall conform as closely as possible to the breadth dimensions of the mandrel to minimize soil disturbance. The projected cross-sectional area of the mandrel and anchor combination shall not be greater than 14 square inches.

- Notify the Engineer at least 3 working days prior to installation of the initial PVDs at the location(s) shown on the plans to allow the Engineer sufficient time to provide the necessary inspection for the initial PVD installation. Do not begin installation of the initial PVDs at the location(s) indicated without the presence of the Engineer or his/her representative. During the installation of the initial 10 PVDs at the indicated location(s), demonstrate that the equipment, method, and material produce a satisfactory installation, as determined by the Engineer. Following completion of the initial PVD installations at the indicated location(s), do not proceed with the installation of the remaining PVDs at the embankment location until authorized by the Engineer.
- If foundations have been previously installed, install the PVDs in a manner as to avoid these foundations. The location of the PVDs relative to the foundations shall be determined and staked out prior to the installation of the PVDs. In addition, take precautions to preserve the stake locations and re-stake PVD locations as necessary.
- Using a baseline and benchmark determined by the Contractor, locate, number, and stake out the PVDs. All other construction staking, for taking precautions to preserve the stake locations, and for re-staking, if necessary, is the responsibility of the Contractor. Do not vary the as-installed locations of the PVDs by more than 6 inches from the locations designated on the plans or approved shop drawings.
- PVDs that deviate from the plan locations by more than 6 inches, that are damaged, or improperly installed will be rejected. Abandon in place rejected PVDs. Replacement PVDs shall be placed as close as possible to the correct original locations.
- Provide the Engineer with a means of verifying the plumb-ness of the mandrel and determining the depth of the PVDs. Check the equipment for plumb-ness prior to installing each PVD. A deviation from the vertical of no more than 2 percent (2%) during installation is allowed.
- Splices, if allowed in the plans or by the Engineer, shall be done in accordance with approved PVD Installation plan.
- Cut off the PVDs neatly at least 6 inches above the working layer, unless otherwise shown on the plans.
- Provide the Engineer with a means of determining the depth of the advancing PVD at any given time and the length of the drain installed at each location. Submit a summary tabulation of the number and length (to nearest 1/2 foot) of acceptable PVD daily to the Engineer.
- Refusal is defined as the point where the soils resist a reasonable effort at further penetration of the PVDs. The Engineer will establish refusal criteria based on the existing soil borings and the initial PVD installations to be performed by the PVD Installer in the presence of the Engineer or his/her inspector, as specified herein. Terminate no PVDs above the design PVD bottom

elevations shown on the plans without the approval of the Engineer. The Engineer may vary the depths, spacing, and/or number of PVDs to be installed, and may revise the plan limits for this work based on the actual subsurface conditions encountered.

- Where obstructions are encountered below the working surface, install a new drain within a 1 foot radius of the original location of the obstructed PVD. As directed by the Engineer make a maximum of 2 additional installation attempts for each obstructed PVD. If the PVD still cannot be installed to the design bottom elevation, abandon the PVD location and install a new PVD at a location directed by the Engineer. Clearly mark in the field locations where PVDs do not meet the depth criteria due to obstructions. The Engineer will have the right to waive the replacement PVD requirement upon written notice to the Contactor and the PVD Installer.
- Pre-augering or spudding for the PVD installation shall be allowed to advance the PVDs through compacted fill material or other obstructions. Penetrate the overlying fill material or any dense layers or obstructions when encountered to satisfactorily install the PVDs. Obstructions are defined as any man-made or natural object or strata that prevents the proper insertion of the mandrel and installation of the PVD.
- The Contractor may use augering, spudding, or other approved methods to loosen the soil and obstructing material prior to the installation of the PVDs. The obstruction clearance procedure is subject to the approval of the Engineer; however, such approval shall not relieve the Contractor or PVD Installer of the responsibility to clear obstructions in accordance with the specifications.
- If augering is the selected method, the augers shall have a minimum outside diameter equal to the largest horizontal dimension of the mandrel, shoe, or anchor, whichever is greatest. The maximum outside diameter of the auger shall be no more than 3 inches greater than the maximum dimension of the mandrel.
- Limit the use of obstruction clearance procedures and use only when approved by the Engineer. Penetrate no more than 3 feet beneath the obstruction when using augering or other obstruction removal techniques.
- Provide the Engineer with “As-Built” plans of the PVD installation. Include in the plans the location, the date installed, and the length of each PVD below the fill soil surface elevation. In addition, include on the “As-Built” PVD plans the fill soil surface elevation at each location, the “As-Built” PVD bottom elevation, and identify any rejected or abandoned PVD installations. Submit “As-Built” plans at least weekly during PVD installation operations. Submit a final “As-Built” PVD plan within 7 calendar days of the completion of PVD installation in all embankment locations. The final “As-Built” plans will be subject to the approval of the Engineer.

627.07 Method of Measurement – Furnish all supervision, materials, equipment, mobilization, crews, tools, required permits, survey stake out of PVD locations, and other equipment and materials as necessary to properly execute the work. In addition, this item includes clearing of obstructions and the proper disposal of surplus materials brought to the ground surface by obstruction clearance, if required.

Mobilization will be paid for by lump sum.

PVDs will be measured and paid for as the number of linear feet satisfactorily installed, or abandoned as directed by the Engineer. Measure the length of acceptably installed PVDs to the nearest 1/2 foot. The length of the PVDs to be paid for shall be the distance the installation mandrel tip penetrates below the working grade plus the required cut-off length above the working surface. Payment will not be made for drains that are not anchored to the required depth, unless previously approved by the Engineer in writing.

The Engineer may vary the depths, spacing, or numbers of PVDs to be installed and may revise the PVD installation limits shown on the plans based on the actual subsurface conditions encountered. Such changes or revisions may increase or decrease the total quantity of the PVDs estimated based on the plans. In the event of such changes in required PVD quantity, the payment for PVDs shall be made on the basis of the contract unit price per linear foot.

Drainage Layer Material will be paid for in cubic yards of material, complete and in place.

627.08 Basis of Payment – Mobilization shall include the cost of furnishing of all equipment and materials necessary to properly execute the work.

PVD payment will be based on the sum total length of all acceptably installed. No payment will be made for PVDs, or for any delays or expenses incurred through changes necessitated by improper material, equipment, or installation. No payment will be made for PVDs placed deeper than the bottom elevation designated on the plans unless authorized in writing by the Engineer. The unit bid price for PVDs shall include the cost of survey and stakeout, installing PVDs, and furnishing all labor, tools, and incidentals necessary to complete the work.

Drainage layer material payment will be based on the sum total cubic yards of material in place. The unit bid price for the drainage layer material shall include the cost of furnishing all labor, tools, and incidentals necessary to complete the work.

Payment will be made under Item Number:

- 627-01.01 Mobilization Lump Sum
- 627-01.02 Prefabricated Vertical Drain Linear Feet
- 627-01.03 Drainage Layer Material Cubic Yard