Approved Products for Lower Volume Local Roads
Publication 447 contains a listing of approved Products or Processes that meet the Bureau of Planning & Research specification requirements and are eligible for Liquid Fuels Funds for use on municipal maintenance and construction projects. Products or Processes listed in this publication must perform satisfactorily and be in compliance with the terms of this publication. All materials accepted on any project shall comply with the applicable section of the Departments specifications or be approved by a Department representative. Publication 447 is issued by the Bureau of Planning & Research to list Products or Processes eligible for use with Liquid Fuels Funds.

For the purpose of this program Lower Volume Local Roads are classified as:

- **Type D roads-Collector Highways** *(rural routes with light to moderate traffic)*
- **Type E roads-Local Access Highways**
- **Municipal or County owned roads** *(roads with light to moderate traffic)*

Publication 447 provides municipalities with a listing of products that are eligible for Liquid Fuels Funds. That does not mean that these are the only products available to municipalities. Products/processes listed in other PennDOT Publications (Publication 408 and Bulletin 15 for example) may be eligible as well. If you have any questions about this please contact your local Municipal Services Representative.

Manufacturers, precasters or fabricators with Products or Processes listed in Publication 447 are required to notify the Bureau of Planning & Research of any change to their contact information. It is required that the Bureau have uninterrupted communication with the Suppliers/Manufacturers of the Products or Processes listed in Publication 447. Non-compliance may result in the removal of the Product or Process from Publication 447.

Product or Process applications must be submitted by the manufacturer, precaster or fabricator to have their company listed in Publication 447. Suppliers or distributors may obtain approved materials from a company listed in Publication 447 for resale to approved contractors.

If it is desired to have a Product or Process included in Publication 447 the applicant shall request a “Bureau of Construction and Materials Product Evaluation Application” (CS-4170). These are available through the PennDOT Website. [http://www.dot.state.pa.us/public/PubsForms/Forms/CS-4170.pdf](http://www.dot.state.pa.us/public/PubsForms/Forms/CS-4170.pdf) or by calling the New Products Evaluation Program Personnel at (717) 783-3721.
Once the Product or Process is approved it will remain in Publication 447 unless one of the following occurs:

A. Failure to meet specification requirements
B. The operation is inactive for two years
C. Failure to notify the Bureau of Planning & Research of major changes in equipment or procedures that affect the quality of the product
D. PennDOT revokes approved status
E. Removal of a plant and/or facility from approved status
F. Any safety related issue
G. Poor performance
H. Hazardous conditions
I. Non-Use

The New Products Evaluation Program for Lower Volume Local Roads and municipal requirements are bound by all applicable sections of Publication 408.

In order to use a Product or Process in Publication 447 an approved MS-329 Project Approval Form is required. Contact your District Municipal Services Representative when you have a project you want to have evaluated and they will complete the MS-329. Publication 9-“Policies and Procedures for the Administration of the County Liquid Fuels Tax Act of 1931 and The Liquid Fuels Tax Act 655 dated 1956 and as Amended” use: contains the appropriate information.

http://www.dot.state.pa.us/public/PubsForms/Publications/PUB%209.pdf
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<td>500-6</td>
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**Certification - Certificate of Compliance**

MS-447-A (1-08)
Section 300

Bituminous Materials & FDR
I. DESCRIPTION — This work is construction of a wearing course of plant mixed bituminous concrete, using modified asphalt cement, on a prepared surface. A Binder type spec for FB3 can be found in ECMS. SECTION 432 - BITUMINOUS PAVING COURSE, FB-MODIFIED.

II. MATERIAL — Publication 408, Section 409.2, modified as shown.

A. Bituminous Material. Modify or use appropriate modifiers, if necessary, to obtain a mix which results in a pavement meeting the performance criteria specified in SSP, Sections 432.3(b)2, and 432.3.(b)2.(s) and which does not exceed 12% oil distillate by volume of the total bituminous binder material when tested in accordance with the procedure specified in SSP, Section 432.2(d). The base bituminous material shall meet the requirements of standard specification for performance graded asphalt binder, AASHTO MP-I except as revised in Department Bulletin 25.

B. Aggregates. Fine Aggregates — Publication 408, Section 703.1. Determine sand equivalent value in accordance with AASHTO T176. If applicable. Minimum sand equivalent value = 40%

Coarse Aggregate — Type A, Publication 408, Section 703.2. Minimum 75% crushed fragments in accordance with PTM No. 621.

C. Composition of Mixture. Test the completed mixture, sampled within 30 seconds of discharge at the plant and placed in a sealed container in accordance with AASHTO T59, Sections 9 thru 13; however, modify the procedure outlined in Section 12 by weighing 850 grams (30 ounces) of a representative sample of the mixture and 50 ml (1.7 ounces) of distilled water in the previously weighed aluminum-alloy still (including lid, clamp, thermometers and gaskets, if gasket is used). This test method will be used for quantitative determination of the percentage of oil distillates in the bituminous mixture by using a ratio of the volume of oil distillate (ml) to the total volume of bituminous binder material (ml) including residual asphalt cement, oil distillates, and water, excluding the 50 ml added for testing. The oil distillate obtained using this test method can be further tested employing qualitative analysis such as gas chromatography (GC) or gas chromatography-mass spectrometry (GC-MS).

1. Uniformity. Perform tests for bitumen content and aggregate gradation as established in the quality control plan and in accordance with PTM No. 1.

2. Acceptance of the Mixture. Obtain material certification from the material producer as specified in Publication 408, Section 106.03(b)3.

Certify using a Department form CS-4171 or TR-465. Send certification to the Inspector-in-Charge within one working day following quality control tests for bitumen content determination and sieve analysis of the mixture.

Table A for FB-3 Wearing:

<table>
<thead>
<tr>
<th>Aggregate</th>
<th>Total Percent by Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Size</td>
<td>% Passing</td>
</tr>
<tr>
<td>12.5 mm (¼ inch)</td>
<td>100</td>
</tr>
<tr>
<td>9.5 mm (⅜ inch)</td>
<td>85-100</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>50-80</td>
</tr>
<tr>
<td>2.36 mm (#8)</td>
<td>10-35</td>
</tr>
<tr>
<td>75 µm (#200)</td>
<td>0-5</td>
</tr>
<tr>
<td>Bitumen % by Weight</td>
<td>(Minimum Residue)</td>
</tr>
<tr>
<td>Stone or Gravel</td>
<td>4.5 %</td>
</tr>
<tr>
<td>Slag</td>
<td>5.0</td>
</tr>
</tbody>
</table>
III. CONSTRUCTION —

A. Bituminous Mixing Plant.

1. Plant Requirements. Obtain plant approval from the Department, prior to manufacturing material. (Should be listed in PUB 41). Equipment for developing the design and control tests, in accordance with the Department’s modified Marshall method, is not required. Mix design must be submitted and approved by materials division before starting.

Use a synchronized, volume-proportioning or weight-proportioning, stationary or portable plant meeting the following requirements:

Aggregate bins and a bituminous tank of sufficient capacity, with heating facilities when required, to assure a constant supply and proper proportioning of materials.

Capable of mixing materials to obtain a uniform coating of particles and a thorough distribution of bituminous material throughout the aggregate.

Positive-driven feed to proportion coarse and fine aggregate from bins and positive pump to proportion bituminous material coming from the tank.

Feeder and pump, synchronized to discharge coarse and fine aggregate and bituminous material in desired proportions for mixing, calibrated prior to actual use.

2. Preparation of Mixture. Coat the aggregate with bituminous material sufficiently forming a film of adequate thickness to provide the required binding properties. Requirements for mixing time and determining the percentage of the aggregate coated, as specified in Bulletin 27, Chapter 1, do not apply. Instead, add the required quantities of aggregate and bituminous material to the mixer, and mix the material to obtain a uniform coating of particles and a thorough distribution of bituminous material. Provide completed mixture which is workable within the ambient temperature range of 32°F to 110°F; yields a durable pavement; is temperature stable without drain-down of bitumen from aggregate; passes all required testing criteria as specified in Bulletin 25, Appendix A; and performs to the satisfaction of the Engineer.

(a) Bituminous Pavers.

The requirement for a heated unit does not apply when the bituminous material used is emulsified asphalt.

(b) Preparation of Existing Surface.

Tack coat requirements apply only when designated in the contract.

(c) Preparation of Existing Surface.

Spread courses to the loose depth needed to obtain the required compacted depth. Spread and strike off the mixture using mechanical equipment for the entire lane width or as much lane as may be practical. Adjust screed assemblies to provide the required cross section and depth.

(d) Compaction.

After the courses have been spread uniformly, compact with a power roller until the mixture is compressed to a firm, even surface. Intermediate rolling with a pneumatic-tire roller is not required, but may be used if approved by the Engineer. Roll the surface when the mixture is in proper condition and when rolling will not cause undue displacement, cracking, or shoving. Use suitable rollers, roller combinations, and rolling patterns to provide required compaction. Continuously roll until the specified compaction is obtained and roller marks are eliminated. Operate rollers slowly enough to avoid displacement of mixture and satisfactorily correct displacement resulting from reversing roller direction or from other causes.
(e) Density Acceptance.

Density acceptance will be determined based on non-motion of material under compaction equipment.

(f) Joints.

When compacting the joint, shift the static steel-wheel roller onto the previously placed lane so only 1 or 2 inches of the drive wheel extends over the uncompacted material. Continue to roll along this line, shifting position gradually across the joint until the joint has been rolled with the entire width of the drive wheel. Roll with steel-wheel and pneumatic-tire rollers until a thoroughly compacted neat joint is obtained.

(g) Protection of Courses.

While the surface is still tacky and before opening to traffic, uniformly spread a layer of fine aggregate on the surface at a rate of 3 to 5 pounds per square yard. Sweep and roll, as directed.

(h) Defective Work.

Unless otherwise directed in writing by the District Engineer, remove and replace pavement deficient in compaction as specified in Section 430.3 (o), or surface tolerance as specified in Section 409.3 (l), or depth where applicable as specified in Section 409.3 (m), or residual asphalt content as specified in Section 409.3 (h) 3.c.

(i) General Performance.

Provide completed pavement which performs to the satisfaction of the engineer without bleeding, rutting, pushing, shoving, raveling, stripping, or showing other types of pavement distress or unsatisfactory performance. Remove and replace unsatisfactory material at no additional cost to the Department.
I. DESCRIPTION - This work is the construction of a penetrated bituminous binder course on a prepared surface.

II. MATERIAL -
A. Bituminous Material. Publication 408, Section 470.2(a)
B. Coarse Aggregate. Type A, No.8 and No. 57, Publication 408, Section 703.2.
C. Bituminous Prime Coat. Publication 408, Section 461.2.

III. CONSTRUCTION -
A. Conditioning Existing Surface. Prior to placing binder course, inspect the existing surface for imperfections or defective areas and correct if necessary. Clean the base or existing surface of foreign materials. Before placing, treat with prime coat, as specified in Publication 408, Section 461.3.

B. Spreading No. 57 Aggregate. Spread the No. 57 coarse aggregate with acceptable spreaders. Remove segregated material and replace with suitable graded material. Spread the aggregate so the binder course will be 2 1/2 inches in depth after final compaction.

C. Compaction No. 57 Aggregate. To compact and bond coarse aggregate, dry-roll it using a 10-ton power roller, as specified in Publication 408, Section 108.05(c).

Start rolling at sides, overlapping shoulders, and progress to center. On superelevated curves, start rolling on the low side and progress to the high side. Roll parallel to the centerline of roadway, lapping each preceding track and covering the entire surface with the rear wheels, until the surface is firm, even, and uniform. Continue rolling, as directed, until the material does not creep or wave ahead of roller wheels.

Along curbs, walls, and at other areas not accessible to the roller, the material should be tamped thoroughly with mechanical or hand tampers. The tampers used should have a minimum weight-to-area ratio of 0.5 pounds per square inch.

D. Test No. 57 Aggregate Thickness and Surface Tolerance. Once the No. 57 aggregate has been spread and rolled, test the depth before applying bituminous materials. The test is executed by digging three holes at approximately 200-foot intervals (one test hole at the center and one at each quarter point). Correct deviations in excess of 1/2 inch by loosening the surface, removing or adding No.5? aggregate, and rerolling the surface.

Before the bituminous application, test the binder course surface, as specified in Publication 408, Section 409.3(1). Correct irregularities of more than 1/2 inch.

E. Application of Bituminous Material. Use a bituminous distributor as specified in Publication 408, Section 460.3(b).

Apply bituminous material when the entire surface is in condition to permit satisfactory penetration and adhesion, when the aggregate is dry, and when the ambient temperature is between the bituminous material application temperature ranges specified in Publication 408, Section 470.2(a) or, if using CRS-1 PM, from 35 to 55°F. Do not apply emulsified asphalt if, in the Qualified Inspector's opinion, rain is imminent or if the Inspector expects freezing temperatures within 24 hours after the application. Do not apply RS-2(E-2), CRS-2(E-3), RS-2PM (E-2M), CRS-2PM (E-3M), or PG 46-40 from September 15 to May 1 in Districts 1-0, 2-0, 3-0, 4-0, 9-0, 10-0, 11-0, 12-0, and 5-0 (Monroe, Carbon, and Schuykill Counties only); and from October 1 to May 1 in Districts 6-0, 8-0, and 5-0 (Berks, Lehigh, and Northampton Counties only).

Apply bituminous material to damp aggregates at a rate of 1.20 to 1.80 gallons/square yard. Increase 10% to 15% when slag is used.

Remove and replace aggregate contaminated with dirt or other foreign substances.
 Depending upon labor and equipment available for handling the aggregate, gage the length of road surface to be penetrated to obtain proper spreading and compaction. Insure uniformity at the junction of two (2) applications.

In areas inaccessible to the distributor, spread bituminous material with portable pressure units.

**F. Spreading No.8 Aggregate.** Immediately after applying the first layer of bituminous material, spread No. 8 aggregate with acceptable spreaders at a rate of 15 to 20 pounds/square yard. Decrease by 13% when slag is used. Spread ahead of the wheels on the spreader so that the bituminous material is covered before the wheels pass over it.

**G. Compaction of No. 8 Aggregate.** After the No. 8 aggregate is spread, start rolling the surface while the bitumen is warm. Broom additional No. 8 aggregate into voids during the rolling process until the entire surface voids are uniformly filled, leaving the No. 57 aggregate completely covered. The equipment and rolling pattern are specified in Subsection III.C.

**H. Mat Density Acceptance.** The Representative will accept density when the mixture does not move under compaction equipment.

**I. Tests for Depth of Binder Course.** After application of No. 8 choke aggregate and after final compaction, test the depth of binder course and correct, if necessary, as specified in Publication 408, Section 409.3(m).

**J. Protection of Binder Course.** Do not allow vehicular traffic or loads on completed binder course until adequate stability has been attained and the material is sufficiently cured to prevent distortion, flushing of bituminous material to surface, or loss of aggregate. Before placing the next application, the binder course must be satisfactorily cured. Maintain and Protect binder course, as provided in Publication 408, Section 901.

**IV. MEASUREMENT AND PAYMENT.**

A. **Bituminous Binder Course CP-2.** Square Yard.

B. **Bituminous Prime Coat.** Publication 408, Section 461.4.
I. DESCRIPTION - This work is the application of bituminous material, immediately followed by application of coarse aggregate.

II. MATERIAL -

A. Bituminous Material. One of the following, as specified in Publication 408 Section 702.

<table>
<thead>
<tr>
<th>Class of Material</th>
<th>Type</th>
<th>Minimum</th>
<th>Maximum</th>
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<tbody>
<tr>
<td>RS-2 (E-2)</td>
<td>Emulsified Asphalt</td>
<td>140</td>
<td>175</td>
</tr>
<tr>
<td>CRS-2 (E-3)</td>
<td>Cationic Emulsified Asphalt</td>
<td>140</td>
<td>175</td>
</tr>
<tr>
<td>RS-2PM (E-2M)</td>
<td>Polymer-Modified Emulsified Asphalt</td>
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<td>CRS-2PM (E-3M)</td>
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<tr>
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<td>Low Temperature Polymer-Modified Cationic Emulsified Asphalt</td>
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<td>140</td>
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<tr>
<td>PG 46-40</td>
<td>Asphalt Cement</td>
<td>240</td>
<td>300</td>
</tr>
</tbody>
</table>

Because of restrictive weather limitations governing the use of CRS-1 PM emulsified asphalt, and the chemistry of the material, use CRS-1 PM emulsions only with the written permission of the District Engineer/Administrator. Provide CRS-1 PM produced by a source listed in Bulletin 15. Use PG 46-40 only on shoulders.

B. Coarse Aggregate. Satisfy requirements for Type A aggregate as specified in Publication 408, Section 703.2, and with the SRL designated in the Contract Item. The flat and elongated particles shall not exceed 10% based on the 5:1 ratio, when measured according to ASTM D 4791. Supply aggregate from a source listed in Bulletin 14. The Contractor may use a aggregate or blends of aggregates with an SRL equal to or better than that specified. Blends are 50% by weight of the two aggregates. Mix the aggregates using an approved method. Aggregate gradation shall follow AASHTO #8 or AASHTO #7, except that the amount of material passing #200 sieve shall not exceed 1 percent.

C. Mix Design. Design the seal coat according to the method in Appendix E of Bulletin 27.

III. CONSTRUCTION - At least 2 weeks before the scheduled start date, submit a seal coat design for the Representative's review. If the source or gradation of aggregate changes or if the type of bitumen changes, submit a new seal coat design.

A. Seasonal Limitations. Do not apply RS-2(E-2), CRS-2(E-3), RS-2PM(E-2M), CRS-2PM(E-3M), or PG 46-40 from September 15 to May 1 in Districts 1-0, 2-0, 3-0, 4-0, 9-0, 10-0, 11-0, 12-0, and 5-0 (Monroe, Carbon, and Schuylkill Counties only); and from October 1 to May 1 in Districts 6-0, 8-0, and 5-0 (Bucks, Lehigh, and Northampton Counties only).

B. Temperature and Weather Limitations. Apply the bituminous material when the ambient temperature exceeds 55°F, and the surface temperature is above 60°F. The ambient temperature range for using CRS-1 PM is 35°F to 55°F. CRS-1 PM is for only Low Temperature seal coat operations. Do not use CRS-1 PM for summer seal-coat projects. Do not apply emulsified asphalt if, in the Representative's opinion, rain is imminent or if the Representative expects the temperature to drop below 35°F within 24 hours after application.

Suspend work in case of wind chill or abnormally high relative humidity.

C. Preparing Existing Surface. Remove and dispose of all unsuitable material. Use a power broom to clean the surface of dust, dirt, and debris. Ensure cleaning is properly extended to the pavement edges. Remove any excess bituminous material from sealed or patched areas before applying the bituminous binder. Use hand scraping or power blading if necessary. Where indicated, seal cracks as specified in Publication 408, Section 469.

D. Application of Bituminous Material. Apply bituminous material when the entire surface is in a condition to allow satisfactory material penetration and adhesion. The surface must be dry at the time of application of the bituminous material.
Ensure the application temperature is within the specified range for the bituminous material. Use a distributor as specified in Publication 408, Section 460.3(b). Use a rate of application within ±1 0% of the design rate. Determine the distributor application rate in the field according to PTM No. 747. Application of the bituminous material must be consistent and uniform in both transverse and longitudinal directions. In case of erratic and non-uniform application, suspend the operation until the problem is properly addressed.

For inaccessible areas, uniformly spread the bituminous material over the surface using portable pressure units. The quantity of material placed at one time shall be consistent with the facilities for handling, spreading, and rolling coarse aggregate, as well as the temperature of the surface and bituminous material.

Uniformly spread the bituminous material at the junction of separate applications.

E. Spreading and Rolling Coarse Aggregate. Use dry aggregates, except the Contractor may use damp aggregates with emulsified asphalt. Before spreading aggregate, calibrate the spreader using a method acceptable to the Inspector-in-Charge. Immediately after applying the bituminous material, uniformly spread a single layer of coarse aggregate at the design rate using a mechanical spreader capable of spreading 15 pounds per square yard to 25 pounds per square yard. The application rate of chips will provide a complete coverage of the surface, with no deficient areas. No asphalt shall cover the aggregate. The spreader shall be self-propelled, equipped with pneumatic tires and equipped with a screen to remove oversized material. The spreader shall follow the bitumen distributor within 100 feet.

Roll the aggregate with pneumatic-tire rollers, as specified in Publication 408, Section 108.05(c)3.f. Provide a sufficient number of rollers to roll the width of stone spread with one pass. Use a contact pressure from 40 pounds per square inch to 50 pounds per square inch. Rollers shall follow the aggregate spreader closely and embed the aggregate into the emulsion before breaking. The roller's speed shall be slow enough to prevent pushing the chips.

F. Protection of Surface. Do not allow vehicular traffic or loads on the newly completed surface until the material obtains adequate stability and adhesion and the material is sufficiently cured to prevent distortion, flushing of bituminous material to the surface, and loss of aggregate.

Provide sufficient flaggers and pilot vehicles to move traffic through the work zone or over the completed work at speeds that prevent aggregate distortion or pick-up. If required, sweep the surface with a power broom to remove loose aggregate before and after opening the road to traffic. Provide a pilot car for sweeping operations after opening the road to traffic.

IV. MEASUREMENT AND PAYMENT -

A. Area Basis. Square Yard

B. Material Used Basis.
   1. Coarse Aggregate. Square Yard
   2. Bituminous Material. Gallon

C. Crack Filling and Sealing. Publication 408, Section 469.4
I. DESCRIPTION- This work is application of bituminous fiber-reinforced material immediately followed by application of coarse aggregate.

II. MATERIAL-

A. Bituminous Seal Coat Material. Polymer-modified Asphalt Emulsion. Publication 408 Section 702(a).

B. Coarse Aggregate. Satisfy requirements for Type A aggregates as specified in Publication 408, Section 703.2(a), with the SRL designated in the Contract Item. The flat and elongated particles shall not exceed 10% based on the 5:1 ratio, when measured according to ASTM D 4791. Supply aggregate from a source listed in Bulletin 14. The Contractor may use an aggregate or blends of aggregate with an SRL equal to or better than that specified. Blends are 50% by weight of each aggregate. Mix the aggregate by an approved method. Aggregate gradation shall follow AASHTO #8 or AASHTO #7, except that the amount of material passing#200 sieve shall not exceed 1 percent.

C. Fiber. Type E-Glass Fiber (ASTM D578-05 (2011), paragraph 4.2.2).
   1. Certify using Municipal Services form MS-447A.

D. Mix Design. Design the seal coat according to the method in Appendix E of Bulletin 27 (Pennsylvania Design Method for Seal Coats and Surface Treatments).

III. CONSTRUCTION- At least 2 weeks before the scheduled start date, submit a seal coat design for the Representative's review. If the source or gradation of aggregate changes or type of polymer-modified asphalt emulsion changes, submit a new design.

A. Seasonal Limitations. Fiber-reinforced seal coat shall be placed between May 1 and September 15 in Districts 1-0, 2-0, 3-0, 4-0, 9-0, 10-0, 11-0, 12-0, and 5-0 (Monroe, Carbon, and Schuylkill Counties only); and between May 1 and October 1 in Districts 6-0, 8-0, and 5-0 (Berkshire, Lehigh, and Northampton Counties only).

B. Temperature and Weather Limitations. Apply the polymer-modified emulsion when the ambient temperature exceeds 55°F and the surface temperature is above 60°F, unless allowed in writing by the Representative. Do not apply polymer-modified asphalt emulsion if, in the Representative's opinion, rain is imminent or if the Representative expects the temperature to drop below 35°F within 24 hours after application. Suspend work in case of wind chill or abnormally high relative humidity.

C. Preparing Existing Surface. Remove and dispose of all unsuitable material. Use a power broom to clean the surface from dust, dirt, and debris. Ensure that cleaning is properly extended to the pavement edges. Remove any excess bituminous material from sealed or patched areas before applying the bituminous binder. Use hand scraping or power blading if necessary. Where indicated, seal cracks as specified in Publication 408, Section 469.3(d).

D. Application of Bituminous Material. Publication 408, Section 470.3(b). Using a specifically designed trailer system, apply bituminous material at a rate of 0.2 gallon per square yard to 0.80 gallon per square yard and the fiber at a rate of 0.055 pounds per square yard to 0.166 pounds per square yard, in accordance with the specific project's requirements. Apply when the entire surface is in a condition to allow satisfactory material penetration and adhesion. Gage quantity of material placed at one time to maintain the requirements for handling, spreading, and rolling coarse aggregate, as well as the temperature of the surface and bituminous material. Ensure uniformity at the junction of two applications. Ensure that the application temperature is within the specified range for the bituminous material. Application of the bituminous material must be consistent and uniform in both transverse and longitudinal directions. In case of erratic and nonuniform application, suspend the operation until the problem is properly addressed.

E. Spreading and Rolling Coarse Aggregate. Before spreading aggregate, calibrate the spreader using a method acceptable to the Inspector-in-charge. Immediately after applying the bituminous material and the fiber, uniformly spread a single layer of coarse aggregate at the design rate using a mechanical spreader capable of spreading 15 pounds per square yard to 25 pounds per square yard. The application rate of chips shall provide a complete coverage of the surface, with no deficient areas. No asphalt shall cover the aggregate. The spreader shall be self-propelled, equipped with pneumatic tires and equipped with a screen to remove oversized material. The spreader shall follow the bitumen distributor within 100 feet.
Roll the aggregate with pneumatic-tire rollers, as specified in Section 1 08.05(c) 3.f. Use a contact pressure from 40 pounds per square inch to 50 pounds per square inch. This surface treatment requires at least two roller passes. Rollers shall follow the aggregate spreader closely and embed the aggregate into the emulsion before breaking. The roller's speed shall be slow enough to prevent pushing the chips.

F. Protection of Surface. Publication 408, Section 470.3(d). Do not allow vehicular traffic or loads on the newly completed surface until the material obtains adequate stability and adhesion and the material is sufficiently cured to prevent distortion, flushing of bituminous material to the surface, and loss of aggregate. Maintain the Work Zone in compliance with Pub. 213.

G. Special Considerations. As per the pre-construction survey, the rate of asphalt and fiber application may need to be adjusted to address the conditions of the surface to be treated. Surfaces that have significant cracks wider than 1/8 inch and/or are severely cracked require a 10% or more increase in the rate of emulsion application. All cracks wider than 1/8 inch need to be sealed in accordance with Publication 408, Section 469.3(d).

IV. MEASUREMENT AND PAYMENT-

A. Area Basis. Square Yard.

B. Material Used Basis.

C. Asphalt Joint and Crack Sealing. Linear Foot. For the type specified.
I. DESCRIPTION — This work involves an application of bituminous fiber reinforced Stress Absorbing Membrane Interlayer (SAMI) material immediately followed by an application of cover aggregate. Cover aggregate is followed by construction of an approved asphalt-based surface overlay.

II. MATERIAL —

A. SAMI.


2. Coarse Aggregate. Type A, No. 8—Publication 408, Section 703.2. Revise the following requirements of Table D:
   - All other uses % Maximum is 1.0.
   - From a Bulletin 14 approved source. Use coarse aggregate with the SRL designation, or better, indicated in the bid proposal.

3. Fiber. Type E-Glass Fiber. (ASTM D578-05, paragraph 4.2.2).
   a. Certify using Municipal Services form MS-447A.

B. Bituminous Overlay.


2. Bituminous Wearing Course FJ-1 and Bituminous Wearing Course FJ-1C. Publication 408, Section 422.2.


4. Bituminous Wearing Course FB-1. Publication 408, Section 439.2.


7. Slurry Seal. Publication 408, Section 482.2.

8. FB-3 Wearing. Publication 447 MS-0310-0011

III. CONSTRUCTION — At least 2 weeks before beginning work, submit a SAMI design to the Representative for review. Use the design method in Appendix E of Bulletin 27 (Pennsylvania Design Method for Seal Coats and Surface Treatments) as a guideline. If source or gradation of aggregate or type of polymer modified asphalt emulsion is changed submit a new design.

A. SAMI.

1. Preparing Existing Surface. Remove and dispose of all unsuitable material. Where indicated, seal cracks as specified in Publication 408, Section 469.3(d).

2. Application of Bituminous Fiber Reinforced Material. Use a trailer system that applies glass fiber between two layers of polymer modified emulsified asphalt. Apply the SAMI when the entire surface is in a condition to allow satisfactory material penetration and adhesion, and when the air, surface, and aggregate temperatures are 16ºC (60ºF) or higher unless allowed in writing by the Representative. Do not apply polymer modified emulsified asphalt if, in the Representative’s opinion, rain is imminent or if freezing temperatures are expected within 24 hours after application. Do not apply RS-2(E-2), CRS-2 (E-3), RS2-PM(E-2M), CRS-2PM(E-3M), or PG 46-40 from September 15 to May 1 in Districts 1-0, 2-0, 3-0, 4-0, 9-0, 10-0, 11-0, 12-0, and 5-0 (Monroe, Carbon, and Schuylkill Counties only); and from October 1 to May 1 in Districts 6-0, 8-0, and 5-0 (Berks, Lehigh, and Northampton Counties only). Apply the SAMI material at a rate of 0.20 gallon per square yard to 0.50 gallon per square yard total for both applications. Determine the distributor application rate in the field in accordance with PTM No. 747. Apply the fiber at a
rate of 0.11 lbs per square yard to 0.221 lbs per square yard, in accordance with the specific projects requirements.

Gage quantity of material placed at one time to maintain the requirements for handling, spreading, and rolling coarse aggregate, as well as the temperature of the surface and the bituminous material. Insure uniformity at the junction of two applications.

3. **Spreading and Rolling Coarse Aggregate.** Before spreading cover aggregate, calibrate the spreader using a method acceptable to the Inspector-in-Charge.

Determine the proper rate of application of coarse aggregate, in accordance with the design, and immediately following the application of bituminous material, use a mechanical spreader to uniformly spread 10 pounds per square yard to 25 pounds per square yard of binding coarse aggregate, in a single layer. Do not use wet aggregates although damp aggregates may be used.

Use sufficient number of pneumatic-tire rollers, as specified in Publication 408, Section 108.05(c) 3.f., with contact pressure of 40 to 50 psi to cover the width of stone spread during the first pass.

4. **Protection of Surface.** Publication 408, Section 470.3(d). Do not allow vehicular traffic or loads on the newly completed surface until the material obtains adequate stability and adhesion and the material is sufficiently cured to prevent distortion, flushing of bituminous material to surface, and/or loss of aggregate. Work Zone must comply with Pub. 213 and the MUTCD.

B. **Bituminous Overlay**

1. **Superpave Mixture Design, Standard and RPS Construction of Plant-Mixed HMA Courses.**
   Publication 408, Section 409.3.

2. **Bituminous Wearing Course FB-2.** Publication 408, Section 430.3.

3. **Bituminous Wearing Course FB-1.** Publication 408, Section 439.3.

4. **Polymer-Modified Emulsified Asphalt Paving System.** Standard Special Provision Item 9400-0200, III.

5. **Ultra-Thin Friction Course.** Standard Special Provision Item 9400-0300, III.

6. **Slurry Seal.** Publication 408, Section 482.3.

7. **FB-3 Wearing.** Publication 447 MS-0310-0011
IV. MEASUREMENT AND PAYMENT —

A. SAMI
1. Area Basis. Square Yard
2. Material Used Basis.
   a. Coarse Aggregate. Square Yard or Ton
      Sq. Yard
   c. Asphalt Joint and Crack Sealing. Linear Foot for the type specified.

B. Bituminous Overlay
2. Bituminous Wearing Course FB-2. Square Yard or Ton.
   b. Mass (Weight) Basis. Ton.
   c. Material Used Basis.
      c1. Aggregate. Square Yard or Ton.
4. Polymer-Modified Emulsified Asphalt Paving System.
   a. Micro-Surfacing.
      a1. Area Basis. Square Yard
      a2. Mass (Weight Basis). Ton
   b. Bituminous Tack Coat. Gallon
   c. Asphalt Joint Crack Sealing. Linear Foot
5. Seal. Square Yard
6. FB-3 Wearing. Wearing Square yard or Ton
I. DESCRIPTION — This work consists of the in-place pulverization and uniform blending of existing roadway surface materials and a predetermined thickness of underlying material creating a homogenous mixture of reclaimed base material. The work also consists of shaping, finishing, fine grading, and compaction of the reclaimed base material.

II. MATERIAL —

A. Reclaimed Material. 95% of the pulverized surface material is required to pass through a 2 inch sieve. Incorporate all reclaimed material into the base.
   1. Reclaimed Aggregate Material (RAM). In-situ aggregate material which is incorporated in the base.

B. Composition of Mixture. Remove samples of RAP and RAM to the specified depth and perform the appropriate testing to determine the appropriate or Optimum Moisture Content (OMC) and corresponding Maximum Dry Density (MDD) use ASTM D698.

III. CONSTRUCTION —

A. Equipment.
   1. Maintain all equipment in a satisfactory operating condition as specified in Publication 408, Section 108.05(c).
   2. Reclaimer. Use a self-propelled rotary reclaimer or equivalent machine capable of cutting through existing roadway materials to depths of up to 16 inches with one pass. Provide equipment capable of pulverizing the existing pavement, base, and subgrade at a minimum width of 8 feet. The cutting drum must have the ability to operate at various speeds (rpm), independent of the machine’s forward speed, in order to control oversized material and gradation.

   Use a machine equipped with a computerized integral liquid proportioning system capable of regulating and monitoring the water application rate relative to depth of cut, width of cut, and speed. Have the water pump on the machine connected by a hose to the supply tanker/distributor, and mechanically or electronically interlocked with the forward movement/ground speed of the machine. Mount the spray bar to allow the water to be injected directly into the cutting drum/mixing chamber.


B. Weather Limitations. Do not place paving mixtures from November 1 to March 31 unless allowed in writing by the District Executive. Do not place mixtures when surfaces are wet or when the air or surface temperature is 40°F or lower.

C. General. Pulverization consists of a series of steps that include pulverizing and mixing of the existing roadway surface between 5-16 inches in depth with the aggregate base. The Motor grader is used to move and place the reclaimed material to the desired longitudinal grade and cross-slope.
D. **Compaction.** Shape, grade, and compact to the lines, grades, and depth shown on the plans and cross sections. Commence rolling at the low side of the course. Leave 3 to 6 inches from any unsupported edge(s) unrolled initially to prevent distortion. When material is too coarse (more than 20% retained on the 3/4 inch sieve and less than 35% passing the Number 200 sieve, or more than 30% retained on the 3/4 inch sieve to use these methods, compaction will be determined on non-movement of material under compaction equipment specified in Publication 408, Section 210.3(a). Compact until pulverized material does not rut under a loaded tri-axle.

E. **Finishing.** Complete all portions of the pulverization during daylight hours, unless otherwise allowed.

F. **Protection.** Protect any finished portion of the pulverized material upon which any construction equipment is required to travel to prevent marring, distortion or damage of any kind. Immediately and satisfactorily correct any such damage.

G. **Surface Tolerance.** When directed by the Inspector, test the completed base course for smoothness and accuracy of grade, both transversely and longitudinally using suitable templates and straightedges. Satisfactorily correct any 3000 square yard area where the average surface irregularity exceeds 1/2 inch under a template or straightedge, based on a minimum of at least three measurements.

IV. **MEASUREMENT AND PAYMENT —**

A. **Pulverized Base.** Square Yard.
Use and Design Guidelines for Evaluating and Determining the appropriate Full Depth Reclamation (FDR) Stabilization Method contained in Publication 447 for use by Municipalities

OBJECTIVE
The purpose of this document is to provide municipalities with a process for determining which FDR Stabilization method is the best for a particular roadway location. The recommended procedure consists of three basic steps which are listed below in the “Process Description” and further discussed in the remainder of the document.

Following this procedure will provide greater assurance of selecting the proper stabilization method and achieving the desired performance of the finished roadway.

INTRODUCTION
“Full Depth Reclamation is the pavement rehabilitation technique in which the full thickness of the asphalt pavement and a predetermined portion of the underlying materials (base, subbase and/or subgrade) is uniformly pulverized and blended to provide an upgraded homogenous base material. Further stabilization may be obtained through the use of available additives.” (Asphalt Recycling and Reclaiming Association (ARRA)).

Four different types of material stabilization are used:

1) Mechanical – Granular materials such as crushed stone, gravel, and/or Reclaimed Asphalt Pavement (RAP) are added to improve the in-place materials.

2) Calcium Chloride – Liquid Calcium Chloride is used.

3) Chemical – Cement, Lime-Pozzolan, and Lime/Fly Ash (L/FA) are used. Hydrated Lime or Fly Ash will not be used as a singular additive, but will be used as a combination of the two.

4) Bituminous – Slow or medium set asphalt emulsions are usually used. Small amounts of hydrated lime or cement, typically 1.5 and 1.0 percent respectively by weight, are being added with asphalt emulsion to produce reclaimed mixtures with higher early strength and greater resistance to water damage.

PROCESS DESCRIPTION
A thorough project evaluation, by the owner, is essential to promote success. Prior to starting the evaluation contact your District Municipal Services Representative.

The project evaluation consists of the following:
1. Roadway Condition Survey
2. Traffic Level and Type
3. Sampling and Testing for Recommended Stabilization Method

1) Roadway Condition Survey
An on-site evaluation of the roadway should be done and take into account the following conditions:

• Grade and Slope of existing roadway
• Evidence of water damage and the underlying cause
• Drainage along shoulders
• Condition of Shoulders if there are shoulders present
• Existing Driving Surface

Other conditions may be observed and should be noted to aid in the final process decision.

2) Traffic Level and Type
Average Daily Traffic (ADT) should suffice on low volume roads. The exception is when heavy vehicle loading is present such as large farm vehicles, quarry traffic, waste material haulers or incidental traffic due to specialized projects (Drilling, etc.).
3) **Sampling and Testing for Recommended Stabilization Method**

A minimum of three sample locations are required per road with additional locations selected upon pavements conditions and variability. Sample locations are to be selected following Pennsylvania Test Method (PTM #1). PTM #1 can be found at the following location.

[www.dot.state.pa.us/public/.../PUBLICATIONS/PUB_19/PTM_TOC.pdf](http://www.dot.state.pa.us/public/.../PUBLICATIONS/PUB_19/PTM_TOC.pdf)

The minimum is 1 (one) sample every 500 linear feet but cannot be less than 3 (three) samples per road. Samples for each roadway are necessary to account for changes in soil conditions that typically occur between different locations. Each sample shall contain sufficient material to perform all the required evaluation testing. Sampling can be done by coring or milling. Samples of asphalt materials, granular base and subgrade soils must be obtained for laboratory evaluation.

**Laboratory Testing**

(Qualified¹ Lab or Technical Representative to be approved by the Municipality).

1) Select a Qualified Laboratory or Technical Representative to do preliminary testing.

2) Samples shall be taken from the field and Table 2 will be used to determine which testing shall be done.

3) Once the preliminary testing is completed the qualified entity will determine which stabilization method(s) to use based on the Characteristics of the Reclaimed Pavement Materials in Table 3.

4) When the qualified entity has determined the recommended stabilization method to use, further testing is done and certified designs are developed to determine the quantities of the recommended additives as outlined in the specification of the recommended stabilization method.

**Tables 2, 3, and 4 are in Appendix A**

Testing of the RAP, the subgrade soils and a mixture of the two will dictate whether an additive is needed, as well as the type and amount to be applied. Minimum testing for RAP shall include an extraction for asphalt content and an aggregate sieve analysis. Minimum testing for soils shall include a sieve analysis, sand equivalent, liquid limit, plastic limit, and plasticity index (PI). General guidelines for selecting stabilizers based on these tests are included in Table 3. Additional strength tests on the stabilized materials can be used in structural design of the pavement.

Laboratory testing may vary considerably because of the wide range of pavement materials and stabilizing agents that are involved. The recycled material can consist of nearly 100% RAP or may contain appreciable amounts of the granular base or soil blended with the RAP. After the stabilization method is determined, further testing is required to determine the quantity of the stabilizing agents (Table 4).

Table 2 lists several tests that can be performed on the reclaimed mixtures. It is important to note that many tests on the asphalt mixture are not conducted unless bituminous stabilization is being considered. Once these tests are performed and the composition of the subject pavement is known it is time to select an additive and determine the mix design.

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¹A Qualified Lab or Technical Representative shall have experience performing the tests required. If there are no Qualified Labs or Technical Representatives in the local area the District Materials Engineer/District Materials Manager (DME/DMM) must approve any requested Lab or Technical Representative.
Additive Selection/Design
To select the type of additive the reclaimed material characteristics are evaluated. Mixture testing is done with the appropriate additives based on the “Characteristics of Reclaimed Pavement Materials” listed in Table 3.

The test procedures in Table 4 are designed to determine the additive amount necessary for achieving adequate structural strength with the in-place combination of soils and RAP. Material variations, especially in the underlying granular soils, usually necessitates structural design based on the worst case scenario to prevent pavement failures.

Additive Selection Guide
Asphalt emulsion is easy to apply and dust free. An emulsion stabilized base course is flexible and is not prone to cracking. When in-place moisture levels are high, adding emulsion can increase moisture contents above optimum resulting in an unstable layer.

Cement is easy to apply dry or as a slurry. Cement improves resistance to moisture and develops good early strength, but shrinkage cracking can be a problem unless cement content is kept low (usually less than 6%).

Calcium Chloride is a hygroscopic chemical (it absorbs moisture). This moisture facilitates compaction and then imparts strength. Calcium Chloride has been shown to reduce frost heaving.

L/FA (Lime/Fly Ash) increases the amount of silicates in silicate deficient silty materials which allows for proper strength gain to take place.

It is important to note when considering these stabilizers that various combinations of them can be used together for various reasons.
Appendix A
### TABLE 2: General Materials Testing for FDR – Laboratory Testing

<table>
<thead>
<tr>
<th>DESCRIPTION OF TEST METHOD</th>
<th>TEST METHOD</th>
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<tbody>
<tr>
<td><strong>Asphalt Mixtures</strong></td>
<td></td>
</tr>
<tr>
<td>Quantitative Extraction of Bituminous Paving Mixtures</td>
<td>PTM #702, AASHTO T164 or ASTM D2172</td>
</tr>
<tr>
<td>Asphalt Content of Hot Mix Asphalt by Ignition Method</td>
<td>PTM #757, AASHTO T308 or ASTM D6307</td>
</tr>
<tr>
<td>Resistance to Plastic Flow of Bituminous Mixtures using Marshall Apparatus</td>
<td>PTM #705, or AASHTO T245 (Modified)</td>
</tr>
<tr>
<td>Bulk Specific Gravity of Compacted bituminous mixtures using Saturated Surface-Dry Specimens</td>
<td>PTM #715, or AASHTO T166</td>
</tr>
<tr>
<td>Sieve or Mechanical Analysis of Extracted Aggregates</td>
<td>PTM #739 (for use with PTM #702, Method D), AASHTO T30 or ASTM D5444</td>
</tr>
<tr>
<td><strong>Granular Base and Soil Materials</strong></td>
<td></td>
</tr>
<tr>
<td>Determining the Plastic Limit and the Plasticity Index of Soils</td>
<td>AASHTO T90 or ASTM D4318</td>
</tr>
<tr>
<td>Plastic Fines in Graded Aggregates and Soils by use of Sand Equivalent Test</td>
<td>AASHTO T176 or ASTM the D2419</td>
</tr>
<tr>
<td>Sieve Analysis of Fine and Coarse Aggregates</td>
<td>PTM #616, AASHTO T27 or ASTM C136</td>
</tr>
<tr>
<td>Materials Finer than No. 200 Sieve in Mineral Aggregates by washing</td>
<td>AASHTO T11 or ASTM C117</td>
</tr>
<tr>
<td>Particle size analysis of Soils</td>
<td>AASHTO T88</td>
</tr>
</tbody>
</table>
### TABLE 3: General Guidelines for Selecting Stabilizers for FDR – Laboratory Testing

<table>
<thead>
<tr>
<th>CHARACTERISTICS OF RECLAIMED PAVEMENT MATERIALS</th>
<th>TYPE AND TYPICAL TRIAL PERCENTS OF STABILIZER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reclaimed asphalt pavement (RAP) having some amount of silty-clay soil from subgrade with a plasticity index (P.I.) greater than 10.</td>
<td>Lime-pozzolan (6-8% by weight) Hydrated Lime (2-6% by weight)&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Materials consisting of 100% RAP or blends of RAP and underlying granular base or soil. The soil fraction can have plasticity or be similar to soils acceptable for lime treatment.</td>
<td>Fly Ash (6-14% by weight)&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Materials consisting of 100% RAP or blends of RAP and underlying granular base or non-plastic or low plasticity soils. There should be sufficient fines to produce an acceptable aggregate matrix for the cement treated base (CTB) produced (not less than 45% passing the No. 4 sieve preferred).</td>
<td>Cement (3-8% by weight)</td>
</tr>
<tr>
<td>Materials consisting of 100% of RAP and underlying granular base or non-plastic or low plasticity soils. The maximum percent passing the 75μm (No. 200) sieve should be less than 25%, the plasticity index less than 6 or the sand equivalent 30 or greater, or the product of multiplying the P.I. and the percent passing the No. 200 sieve being less than 72.</td>
<td>Emulsified Asphalt (1.5-4.5% by weight)&lt;sup&gt;2&lt;/sup&gt; Determine the optimum emulsion content based on the averages for maximum stability and maximum density for the mixture specimen.</td>
</tr>
<tr>
<td>Materials consisting of a blend of RAP and non-plastic base soils with 8-12% minus 75 micron material. Small amounts of clay 3-5% are also beneficial.</td>
<td>Calcium Chloride (35% minimum solution at a rate of 0.10 to 0.15 gallons/square yard for every inch of depth).</td>
</tr>
</tbody>
</table>

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<sup>1</sup>Hydrated Lime or Fly Ash will not be used as a singular additive but will be used as a combination of the two. This combination will be referred to as Lime/Fly Ash (L/FA).

<sup>2</sup>Small amounts of hydrated lime or cement, typically 1.5 and 1.0 percent respectively by weight, are being added with asphalt emulsion to produce reclaimed mixtures with higher early strength and greater resistance to water damage.
<table>
<thead>
<tr>
<th>TYPE OF STABILIZER</th>
<th>TESTING PROCEDURES APPLICABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrated Lime (2 to 6% by weight)</td>
<td>Liquid Limit, Plastic Limit and Plasticity Index of Soils, AASHTO T90 or ASTM D4318 Moisture</td>
</tr>
<tr>
<td>Lime-Pozzolan (6 to 8% by weight)</td>
<td>Density Relations of Soils and Soil-Aggregate Mixtures, AASHTO T99 or ASTM D698 or D1557</td>
</tr>
<tr>
<td></td>
<td>Unconfined Compressive Strength of Compacted Lime Mixtures, ASTM D5102, Procedure B</td>
</tr>
<tr>
<td>Fly Ash (6 to 14% by weight)</td>
<td>Moisture-Density Relations of Soil-Cement mixtures. AASHTO T134 or ASTM D558, Method B</td>
</tr>
<tr>
<td>Cement (3 to 8% by weight)</td>
<td>Compressive Strength of Molded Soil-Cement Mixtures, ASTM D1633</td>
</tr>
<tr>
<td></td>
<td>Wetting and Drying Compacted Soil-Cement Mixtures, ASTM D559, Test Method B</td>
</tr>
<tr>
<td>Asphalt Emulsion (1.5 to 4.5% by weight)</td>
<td>Refer to Guidelines and design process for Full Depth Reclamation listed in Chapter 2, Section 7 of Bulletin 27 “Bituminous Concrete Mixtures, Design Procedures and Specifications for Special Bituminous Mixtures.”</td>
</tr>
<tr>
<td>Calcium Chloride (Use a minimum of 35% solution at a rate of depth, 0.10 to 0.15 gallons/square yard for every inch of depth).</td>
<td>Liquid Limit, Plastic Limit and Plasticity Index of Soils, AASHTO T90 or ASTM D4318 Moisture Density Relations of Soils and Soil-Aggregate Mixtures, AASHTO T99 or ASTM D698 or D1557</td>
</tr>
</tbody>
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I. DESCRIPTION — This work consists of the incorporation of imported granular materials during the pulverization or mixing pass of a FDR project. Provide reclaimed base course manufactured by in-place pulverizing and uniform blending of the existing roadway surface material and any underlying granular material, thus creating a homogenous mixture of reclaimed base material. The work also consists of shaping, finishing, fine grading, and compaction of the reclaimed base material.

II. MATERIAL —

A. Reclaimed Material. 95% of the pulverized surface material is required to pass through a 2 inch sieve. Incorporate all reclaimed material into the stabilized base course.

1. Reclaimed Aggregate Material (RAM). In-situ aggregate material which is incorporated in the stabilization.


B. Aggregate. Publication 408, Section 703.2. (Type A), No. 8, 10, 57, and 67. Add the gradation and quantity to the mix as required.

C. Composition of Mixture. Remove samples of RAP and RAM to the specified depth and perform the appropriate testing to establish the final aggregate quantity and gradation. To determine the appropriate or Optimum Moisture Content (OMC) and corresponding Maximum Dry Density (MDD) use ASTM D698. Submit the results to the District Materials Engineer/District Materials Manager (DME/DMM) for approval at least three weeks before commencement of work on the project. Provide the work plan to the Municipality five (5) working days before the start of work.

Approval of the results by the DME/DMM is solely for monitoring and quality control and in no way releases the Contractor from his responsibilities.

III. CONSTRUCTION —

A. Equipment. Use equipment that produces the completed mechanical stabilized base course as follows:

1. Maintain all equipment in a satisfactory operating condition as specified in Publication 408, Section 108.05(c).

2. Reclaimer. Use a self-propelled rotary reclaimer or equivalent machine capable of cutting through existing roadway materials to depths of up to 16 inches with one pass. Provide equipment capable of pulverizing “In-place” the existing pavement, base, and subgrade at a minimum width of 8 feet, and mixing any added materials to the specified depth. The cutting drum must have the ability to operate at various speeds (rpm), independent of the machines forward speed, in order to control oversized material and gradation.

   Use a machine equipped with a computerized integral liquid proportioning system capable of regulating and monitoring the water application rate relative to depth of cut, width of cut, and speed. Have the water pump on the machine connected by a hose to the supply tanker/distributor, and mechanically or electronically interlocked with the forward movement/ground speed of the machine. Mount the spray bar to allow the water to be injected directly into the cutting drum/mixing chamber. Provide equipment capable of mixing water, aggregate, and the pulverized pavement materials into a homogenous mixture. Keep the cutting drum fully maintained and in good condition at all times throughout the project.

   Equipment such as road planers or cold-milling machines designed to mill or shred the existing roadway materials rather than crush or fracture it is not allowed.


B. **Weather Limitations.** Do not place paving mixtures from November 1 to March 31 unless allowed in writing by the District Executive. Do not place mixtures when surfaces are wet or when the air or surface temperature is 40ºF or lower.

C. **General.** FDR consists of a series of steps that include pulverization and mixing of the existing roadway surface between 5-16 inches in depth with the aggregate base. Mechanical stabilizers can be spread either ahead of the pulverization pass or incorporated into a blending pass after pre-pulverization and shaping. The motor grader is used to move and place the reclaimed material to the desired longitudinal grade and cross-slope.

D. **Compaction.** Shape, grade, and compact to the lines, grades, and depth shown on the plans and cross sections after the material has been processed. Maintain material to within ±3% of the optimum moisture content at the time of compaction. Commence rolling at the low side of the course. Leave 3-6 inches from any unsupported edge(s) unrolled initially to prevent distortion.

Determine in-place density requirements by the construction of at least one control strip under the guidance of a nuclear gauge operator. After each pass of the compaction equipment take a nuclear density reading in accordance with PTM No. 402. Continue compaction with each piece of equipment until no appreciable increase in density is obtained by additional passes. Upon completion of compaction, make a minimum of ten tests at random locations to determine the average in-place density of the control strip. Record and provide the results to the Municipality.

Compact the mechanically stabilized base course to a target density of at least 98% of the density requirements of the control strip. Determine the in-place density in accordance with PTM No. 402 for each 3000 square yard area. If the density of an area is less than the minimum density, but the base course is uniform in texture, stable and otherwise acceptable, try additional compaction. If additional compaction does not achieve the minimum density, complete an additional control strip in order to verify that proper density is being obtained. Take a minimum of five tests at random locations to determine the average in-place density of the control strip. The new minimum density is 98% of the average in-place density from the control strip.

E. **Finishing.** Complete all portions of the mechanical stabilized base course during daylight hours, unless otherwise allowed.

F. **Protection.** Protect any finished portion of the mechanical stabilized base course upon which any construction equipment is required to travel to prevent marring, distortion or damage of any kind. Immediately and satisfactorily correct any such damage.

G. **Surface Tolerance.** When directed by the Inspector, test the completed mechanical stabilized base course for smoothness and accuracy of grade, both transversely and longitudinally using suitable templates and straightedges. Satisfactorily correct any 3000 square yard area where the average surface irregularity exceeds 1/2 inch under a template or straightedge, based on a minimum of at least three measurements.

IV. MEASUREMENT AND PAYMENT —

A. **Stabilized Base.** Square Yard.

B. **Aggregate.** Ton.
I. DESCRIPTION — This work consists of the pulverizing and mixing of a combination of virgin aggregate (if/where specified), reclaimed asphalt pavement (RAP), reclaimed aggregate material (RAM), and calcium chloride to the specified length, width, and depth. This work also consists of shaping, finishing, fine grading, and compaction of the stabilized base material.

II. MATERIAL —

A. Reclaimed Material. 95% of the pulverized surface material is required to pass through a 2 inch sieve. Incorporate all reclaimed material into the stabilized base course.

1. Reclaimed Aggregate Material (RAM). In-situ aggregate material which is incorporated in the stabilization.


B. Stabilizing Additive.

1. Calcium Chloride. Publication 408, Section 721. Use a minimum of 35% solution at a rate of 0.10 to 0.15 gallons/square yard for every inch of depth.

C. Aggregate. Publication 408, Section 703.2 (Type A), No. 8, 10, 57, and 67. Add the gradation and quantity to the mix as required.

D. Mix Design. Remove samples of RAP and RAM to the specified depth and perform appropriate laboratory testing to establish mix design. To determine the appropriate or Optimum Moisture Content (OMC) and corresponding Maximum Dry Density (MDD) use ASTM D698. Submit mix design to the District Materials Engineer/District Materials Manager (DME/DMM) for approval three weeks before the planned start of work. Provide an approved mix design and work plan to the Municipality five (5) working days before the planned start of work.

Approval of the mix design by the DME/DMM is solely for monitoring quality control and in no way releases the Contractor from his responsibilities.

Mix Design Development. Core samples will be obtained inclusive of the depth to be recycled. Sampled materials must be properly processed and prepared to closely simulate field conditions. A Qualified Laboratory Technician shall analyze the samples and provide the following information as part of the mix design to the DME/DMM.

1. Location of core samples.
2. Thickness and description of existing pavement and aggregate layers to be reclaimed.
3. A selected matrix of soils testing standards.

   Moisture Content. ............................................ AASHTO T265
   Sieve Analysis. ............................................. PTM 616
   Material Finer than No. 200 sieve. ................. PTM 100
   Moisture Density Relationship. ..................... PTM 106

E. Mixture. Combine the reclaimed material, aggregates (if necessary), and calcium chloride, and water according to the mix design and at the mix design recommended moisture content. If conditions change make field adjustments as recommended in the mix design under the guidance of the Inspector or Qualified Laboratory Technician to obtain a satisfactory stabilized base course.
III. CONSTRUCTION —

A. Equipment. Use equipment that will produce the completed chemical stabilized base course as follows:

1. Use equipment capable of automatically metering liquids with a variation of not more than ±2% by mass (weight) of liquids. Calibrate before use.

2. Maintain all equipment in a satisfactory operating condition as specified in Publication 408, Section 108.05(c).

3. Reclaimer. Use a self-propelled rotary reclaimer or equivalent machine capable of cutting through existing roadway material to depths of up to 16 inches with one pass. Provide equipment capable of pulverizing “In-place” the existing pavement base and subgrade at a minimum width of 8 feet, and mixing any added materials to the specified depth. The cutting drum must have the ability to operate at various speeds (rpm), independent of the machines forward speed, in order to control oversized material and gradation.

   Use a machine equipped with a computerized integral liquid proportioning system capable of regulating and monitoring the liquid application rate relative to depth of cut, width of cut, and speed. Have the liquid pump on the machine connected by a hose to the supply tanker/distributor, and mechanically or electronically interlocked with the forward movement/ground speed of the machine. Mount the spray bar to allow the liquid to be injected directly into the cutting drum/mixing chamber. Provide equipment capable of mixing Calcium Chloride and the pulverized pavement materials into a homogenous mixture. Keep the cutting drum fully maintained and in good condition at all times throughout the project.

   Equipment such as road planers or cold-milling machines designed to mill or shred the existing roadway materials rather than crush or fracture it is not allowed.


B. Weather Limitations. Do not place paving mixtures from November 1 to March 31, unless allowed in writing by the District Executive. Do not place mixtures when surfaces are wet or when the air or surface temperature is 40°F or lower.

C. General. FDR consists of a series of steps that include pulverization and mixing of the existing roadway surface between 5-16 inch in depth with the aggregate base and subgrade soil. Calcium Chloride can be injected through the machines computerized integral liquid proportioning system during the pulverization pass or incorporated into a blending pass after pre-pulverization and shaping. The motor grader is used to move and place the reclaimed material to the desired longitudinal grade and cross-slope.

D. Pulverization/Stabilization/Mixing. Pulverize and mix the roadway material to a minimum depth of 5 inches. Thoroughly mix the existing roadway materials together at the design specified treatment depth while surface adding or injecting the design specified amount of Calcium Chloride to create a homogenous stabilized mixture. Rough grade to desired cross slope and profile. Apply the designed quantity of calcium chloride and liquid to assure proper compaction.
E. **Compaction.** Shape, grade and compact to the lines, grades, and depth shown on the plans and cross sections after the material has been processed. The moisture content before compaction should be at or no more than ±3% over Optimum Moisture Content (OMC). Allow the mixture to cure as necessary before rolling. Commence rolling at the low side of the course. Leave 3 to 6 inches from any unsupported edge(s) unrolled initially to prevent distortion.

Determine the in-place density requirements by the construction of at least one control strip under the guidance of a nuclear gauge operator. After each pass of the compaction equipment take a nuclear density reading in accordance with PTM No. 402. Continue compaction with each piece of equipment until no appreciable increase in density is obtained by additional passes. Upon completion of compaction, make a minimum of ten tests at random locations to determine the average in-place density of the control strip. Record and provide the results to the Municipality.

Compact the Calcium Chloride stabilized base course to a target density of at least 98% of the average in-place density of the control strip. Determine the in-place density in accordance with PTM No. 402 for each 3,000 square yard area. If the density of an area is less than the minimum density but the base course is uniform in texture, stable and otherwise acceptable, try additional compaction. If additional compaction does not achieve the minimum density complete an additional control strip in order to verify that proper density is being obtained. Take a minimum of five tests at random locations to determine the average in-place density of the control strip. The new minimum density is 98% of the average in-place density.

If it is determined that the contractor is achieving the target density with minimum compactive effort, the Inspector may require a new control strip to verify or establish a new target density.

If the completed Calcium Chloride stabilized base course is unacceptable for any reason do not continue construction until the cause of the deficiency (ies) is determined and corrected.

F. **Finishing.** Complete all portions of the calcium chloride stabilized base course during daylight hours, unless otherwise allowed.

G. **Protection.** Protect any finished portion of the calcium chloride stabilized base course upon which any construction equipment is required to travel to prevent marring, distortion or damage of any kind. Immediately and satisfactorily correct any such damage.

H. **Surface Tolerance.** When directed by the Inspector, test the completed calcium chloride stabilized base course for smoothness and accuracy of grade, both transversely and longitudinally using suitable templates and straightedges. Satisfactorily correct any 3000 square yard area where the average surface irregularity exceeds 1/2 inch under a template or straightedge, based on a minimum of at least three measurements.

I. **Curing.** Allow the calcium chloride stabilized base course to cure for at least 5 days after final compaction has been completed. Protect the surface from drying.

IV. **MEASUREMENT AND PAYMENT —**

A. **Chemical Stabilized Base.** Square Yard.

B. **Aggregate.** Ton.

C. **Calcium Chloride.** Gallon.
I. DESCRIPTION — This work consists of pulverizing and mixing a combination of virgin aggregate (if/where specified), Reclaimed Asphalt Pavement, Reclaimed Aggregate Material, and Subgrade Material to the specified length, width, and depth. Once pulverized, add the Chemical Stabilizing additives as per Project Mix Design, and mix the materials together to create a chemically stabilized base course. This work also consists of shaping, finishing, fine grading, and compaction of the reclaimed base material.

II. MATERIAL —

A. Reclaimed Material. 95% of the pulverized surface material is required to pass through a 2 inch sieve. Incorporate all reclaimed material into the stabilized base course.
   1. Reclaimed Aggregate Material (RAM). In-situ aggregate material which is incorporated in the stabilization.

B. Stabilizing Agent.
   1. Cement. Publication 408, Section 701. (3 to 8% by weight).
   2. *Hydrated Lime. Publication 408, Section 723. (2 to 6% by weight).
   4. Lime Pozzolan. Publication 408, Section 725. (6 to 8% by weight).

* Hydrated Lime or Fly Ash will not be used as a singular additive but will be used as a combination of the two. This combination shall be referred to as Lime/Fly Ash (L/FA).

C. Aggregate. Publication 408, Section 703.2 (Type A), No. 8, 10, 57, and 67. Add the gradation and quantity to the mix as required.

D. Mix Design. Remove samples of RAP and RAM to the specified depth and perform appropriate laboratory testing to establish mix design. Submit mix design to the District Materials Engineer/District Materials Manager (DME/DMM) for approval three weeks before the planned start of work. Provide an approved mix design and work plan to the Municipality five (5) working days before the planned start of work.

Approval of the mix design by the DME/DMM is solely for monitoring quality control and in no way releases the Contractor from his responsibilities.

Mix Design Development. Samples must be obtained inclusive of the depth to be recycled. Sampled materials must be properly processed and prepared to closely simulate field conditions. A Qualified Laboratory Technician will analyze the samples and provide the following information as part of the mix design to the DME/DMM.

1. Location of core samples.
2. Thickness and description of existing pavement and aggregate layers to be reclaimed.
3. A selected matrix of soils testing standards.

   Moisture Content ................................. AASHTO T265
   Sieve Analysis ................................. PTM 616
   *Mechanical and Hydrometer
   Particle Size Analysis of Soils ................. AASHTO T88-90
   *Liquid Limit, Plastic Limit ................. AASHTO T89
   Moisture Density Relationship ............... PTM 106
   Unconfined Compression ...................... AASHTO T208
   Material Finer than No. 200 Sieve .......... PTM 100

* To be performed only if more than 20% of the underlying subgrade is to be included in the chemically stabilized layer.
1. **Strength Requirements** —

A. **Cement.** Make, cure, and test three unconfined compressive strength specimens of FDR material and Cement in accordance with ASTM 1633, method A. Wrap the specimens in plastic wrap, seal in an airtight, moisture proof bag and cure the test specimens for a period of 7 days. For the final mix design, the required amount of cement will be that which provides an average unconfined compressive strength of the three specimens of:

A minimum unconfined compression value of 200 psi in 7 days and a maximum unconfined compression value of 500 psi in 7 days for roads that are designed with a minimum of 3 inch pavement overlay.

A minimum unconfined compression value of 300 psi in 7 days and a maximum unconfined compression value of 500 psi in 7 days is required for roads that are to be Surface Treated or overlaid with less than 3 inch of pavement.

B. **Lime/Fly Ash (L/FA), Lime Pozzolan and combinations there-of.** Make, cure, and test three unconfined compressive strength specimens of FDR material and L/FA or Lime Pozzolan in accordance with ASTM 5203, procedure B. Wrap the specimens in plastic wrap, seal in an airtight, moisture proof bag and cure the test specimens for a period of 7 days at 104°F before testing. For the final mix design, the required amount of L/FA or Lime Pozzolan will be that which provides an average unconfined compressive strength of the three specimens of at least 200 psi.

C. **Mixture.** Combine the reclaimed material, aggregates (if necessary), stabilizing additive(s), and water according to the mix design and at the mix design recommended moisture content. If conditions change make field adjustments as recommended in the design under the guidance of the Inspector and Qualified Laboratory Technician to obtain a satisfactory Stabilized Base Course.

III. **CONSTRUCTION** —

A. **Equipment.** Use equipment that will produce the completed chemical stabilized base course as follows:

1. Use equipment capable of automatically metering liquids with a variation of not more than ±2% by mass (weight) of liquids. Calibrate before use.
2. Maintain all equipment in a satisfactory operating condition as specified in Publication 408, Section 108.05(c).
3. **Reclaimer.** Use a self-propelled, traveling rotary reclaimer or equivalent machine capable of cutting through existing roadway material to depths of up to 16 inches with one pass. The equipment will be capable of pulverizing "In-place" the existing pavement, base and subgrade at a minimum width of 8 feet, and mixing any added materials to the specified depth. The cutting drum must have the ability to operate at various speeds (rpm), independent of the machines forward speed, in order to control oversized material and gradation.

   Use a machine equipped with a computerized integral liquid proportioning system capable of regulating and monitoring the water application rate relative to depth of cut, width of cut, and speed. Have the water pump on the machine connected by a hose to the supply tanker/distributor, and mechanically or electronically interlocked with the forward movement/ground speed of the machine. Mount the spray bar to allow the water to be injected directly into the cutting drum/mixing chamber. Provide equipment capable of mixing water, dry additives, and the pulverized pavement materials into a homogenous mixture. Keep the cutting drum fully maintained and in good condition at all time throughout the project.

   Equipment such as road planers or cold-milling machines designed to mill or shred the existing roadway materials rather than crush or fracture it is not allowed.


B. Weather Limitations. Do not place paving mixtures from November 1 to March 31 unless allowed in writing by the District Executive. Do not place mixtures when surfaces are wet or when the air or surface temperature is 40°F and falling.

C. General. FDR consists of a series of steps that include pulverization and mixing of the existing roadway surface between 5-16 inch in depth with the aggregate base. The motor grader is used to move and place the reclaimed material to the desired longitudinal grade and cross-slope.

D. Pulverization/Shaping. Before the application of any stabilizing additives pulverize the roadway materials to the depth specified by the project mix design. Shape to within 3/4 inch of irregularity to the lines, grades and/or cross-slope of the proposed roadway and compacted until no further densification is achieved. Water will be added to the pulverized material to adjust the moisture content to at least Optimum Moisture Content (OMC), but no more than ±3% over OMC. Addition of this water can be done through the machines liquid additive system and/or through top watering. After acceptance by the DME/DMM the additive spreading and mixing will be done as described below.

1. Additive Application.
   a. Cement, Lime/Fly Ash (L/FA), Lime Pozzolan and combinations there-of. Upon completion of the pulverization pass the stabilizing additives previously outlined will be applied at the rate established by the DME/DMM approved project mix design. The additive will be accurately and uniformly spread on the pulverized pavement by using an adjustable rate auger/vane type dry additive distributor. The contractor will provide a 1-square yard of canvas and scale to check the application rate of the spreader. Dry additives will be spread in a manner to minimize dusting. The dry additive will not be applied when the wind conditions in the opinion of the DME/DMM, are such that blowing additives become objectionable to traffic or adjacent property owners. Manual and/or gravity (tail gate) spreading of the additives is unacceptable.
   b. Lime or Cement Slurry. If slurries are to be used, the distributor and tanker trucks will be equipped with a recirculating pump and/or agitation system to prevent settling of the materials before application.

E. Stabilization/Mixing. Once the additives are applied thoroughly mix the additives and pulverized pavement together at the design specified treatment depth while simultaneously injecting any additional water needed (if any) through the machines computerized integral liquid proportioning system to create a homogenous mixture. The moisture content before compaction must be at or no more than 3% over OMC.

F. Compaction. Shape, grade and compact to the lines, grades, and depth shown on the plans and cross sections after the material has been processed. The moisture content before compaction must be at or no more than 3% over OMC. Allow the mixture to cure as necessary before rolling. Commence rolling at the low side of the course. Leave 3 to 6 inches from any unsupported edge(s) unrolled initially to prevent distortion.

Determine the in-place density requirements by the construction of at least one control strip under the guidance of a nuclear gauge operator. After each pass of the compaction equipment take a nuclear density reading in accordance with PTM No. 402. Continue compaction with each piece of equipment until no appreciable increase in density is obtained by additional passes. Upon completion of compaction, make a minimum of ten tests at random locations to determine the average in-place density of the control strip. Record and provide results to the Municipality.
Compact the chemically stabilized base course to a target density of at least 98% of the average in-place density of the control strip. Determine the in-place density in accordance with PTM No. 402 for each 3000 square yard area. If the density of an area is less than the minimum density, but the base course is uniform in texture, stable and otherwise acceptable, try additional compaction.

If additional compaction does not achieve the minimum density, complete an additional control strip in order to verify that proper density is being obtained. Take a minimum of five tests at random locations to determine the average in-place density of the control strip. The new minimum density is 98% of the average in-place density.

If it is determined that the contractor is achieving the target density with minimum compactive effort, the Inspector may require a new control strip to verify or establish a new target density.

If the completed chemically stabilized base course is unacceptable for any reason do not continue construction until the cause of the deficiency (ies) is determined and corrected.

G. **Finishing.** Complete all portions of the chemical stabilized base course during daylight hours, unless otherwise allowed.

H. **Protection.** Protect any finished portion of the chemical stabilized base course upon which any construction equipment is required to travel to prevent marring, distortion or damage of any kind. Immediately and satisfactorily correct any such damage.

I. **Surface Tolerance.** When directed by the Inspector, test the completed chemical stabilized base course for smoothness and accuracy of grade, both transversely and longitudinally using suitable templates and straightedges. Satisfactorily correct any 3000 square yard area where the average surface irregularity exceeds 1/2 inch under a template or straightedge, based on a minimum of at least three measurements.

J. **Curing.** Do not allow traffic on the newly constructed chemical stabilized base course until it cures unless otherwise directed in writing by the Municipality. Allow the chemical stabilized base course to cure for at least five days after final compaction has been completed. Protect the surface from drying and apply a bituminous prime coat, or DME/DMM approved equivalent over the entire surface within 24 hours of final compaction of the stabilized base course. Apply at a rate of 0.21 gallons per square yard. Use emulsified asphalt meeting the requirements of Publication 408, Section 461.2(a). Where the surface is utilized for maintaining traffic the application of the bituminous material shall be immediately followed by the application of an approved cover aggregate.

**IV. MEASUREMENT AND PAYMENT —**

A. **Chemical Stabilized Base.** Square Yard.

B. **Aggregate.** Ton.

C. **Stabilizing Additives.**
   1. **Cement.** Ton.
   2. **Hydrated Lime.** Ton.
   3. **Fly Ash.** Ton.
   4. **Lime-Pozzolan.** Ton.

D. **Bituminous Prime Coat.** Square Yard or Gallon.
I. DESCRIPTION — This work consists of the incorporation of bituminous stabilization materials during the pulverization or mixing pass of a FDR project. This work also consists of shaping, finishing, fine grading, and compaction of the reclaimed base material.

II. MATERIAL —

A. Reclaimed Material. 95% of the pulverized surface material is required to pass through a 2 inch sieve. Incorporate all reclaimed material into the stabilized base course.

1. Reclaimed Aggregate Material (RAM). In-situ aggregate material which is incorporated in the stabilization.


B. Bituminous Material. Add to the mix the type and quantity of bituminous material as determined by the approved mix design. Use bituminous material conforming to the applicable requirements of Bulletin 25. Use one of the following:

1. Emulsified Asphalt. SS-1 (E6A), CSS-1 (E6-C), SS-1h (E-8A), CSS-1h (E-8C), HFMS-2 (E-11-90), HFMS-2s (E-11-150), HFMS-2h (E-11-60). Polymer modified versions of the above materials can be used as necessary, conforming to the requirements in Publication 242, Chapter 5. (1.5 to 4.5% by weight typical).

C. Aggregate. Publication 408, Section 703.2 (Type A), No. 8, 57, and 67. Add the gradation and quantity to the mix as required.

D. Mix Design. Remove samples of RAP and RAM to the specified depth and perform the appropriate laboratory testing to establish the mix design. Guidelines and design process for full depth reclamation are listed in Chapter 2 of Bulletin 27 “Bituminous Concrete Mixtures, Design Procedures and Specifications for Special Bituminous Mixtures.” Determine the theoretical maximum specific gravity according to AASHTO T-209 on the designed mixture at the optimum emulsified asphalt content. Submit the mix design to the District Materials Engineer/District Materials Manager (DME/DMM) for approval three weeks before the start of work. Provide an approved mix design and work plan to the Municipality five (5) working days before the start of work.

Approval of the mix design by the DME/DMM is solely for monitoring quality control and in no way releases the Contractor from his responsibilities.

F. Mixture. Combine the reclaimed material, aggregates (if necessary), and bitumen, in such proportions that the total aggregate and bitumen in the reclaimed mix conform to the requirements and composition specified in the mix design with the recommended optimum moisture and emulsion content. When composition varies sufficiently, make field adjustments as recommended in the design to obtain completed bituminous stabilized base course, with satisfactory particle coating and optimum compaction.
III. CONSTRUCTION —

A. Equipment. Use equipment that produces the completed bituminous stabilized base course as follows:

1. Use equipment capable of automatically metering liquids with a variation of not more than ±2% by mass (weight) of liquids. Contractor must provide current year calibration to Municipality.

2. Maintain all equipment in a satisfactory operating condition as specified in Publication 408, Section 108.05(c).

3. Reclaimer. Use a self-propelled, traveling rotary reclaimer or equivalent machine capable of cutting through existing roadway material to depths of up to 16 inches with one pass. The equipment will be capable of pulverizing “In-place” the existing pavement, base, and subgrade at a minimum width of 8 feet, and mixing any added materials to the specified depth. The cutting drum must have the ability to operate at various speeds (rpm), independent of the machines forward speed, in order to control oversized material and gradation.

   Use a machine equipped with a computerized integral liquid proportioning system capable of regulating and monitoring the liquid application rate relative to depth of cut, width of cut, and speed. Have the liquid pump on the machine connected by a hose to the supply tanker/distributor, and mechanically or electronically interlocked with the forward movement/ground speed of the machine. Mount the spray bar to allow liquids to be injected directly into the cutting drum/mixing chamber. Provide equipment capable of mixing liquids, dry additives, and the pulverized pavement materials into a homogenous mixture. Keep the cutting drum fully maintained and in good condition at all times throughout the project.

   Equipment such as road planers or cold-milling machines designed to mill or shred the existing roadway material rather than crush or fracture it is not allowed.


B. Weather Limitations. Do not place base course from September 1 to April 30 in Districts 1-0, 2-0, 3-0, 4-0, 9-0, and 10-0; and from October 1 to April 1 in all other districts. With written approval of the District Executive, the Contractor may place base course when no freezing temperatures occur for 24 hours before paving and when the project ambient temperature is 45ºF and rising.

C. General. FDR consists of a series of steps that include pulverization and mixing of the existing roadway surface between 5-16 inches in depth with the aggregate base and subgrade soil. Bituminous stabilizers will be incorporated during a blending pass after pre-pulverization and shaping. The motor grader is used to move and place the reclaimed material to the desired longitudinal grade and cross-slope.

D. Mixing. Maintain adequate total liquids to ensure total mixing of the reclaimed material and aggregate (if required) with the bituminous material. Add liquid to the surface by a calibrated meter as necessary to aid in mixing and compaction.

   Upon completion of the pulverization pass, Asphalt Emulsion will be applied at the rate established by the approved mix design. Asphalt Emulsion will be injected through the machines computerized integral liquid proportioning system with a variation of not more than ±2% by mass (weight) of liquids. Extreme care must be taken to verify that material usage/yield is accurate.

   Measure the milling depth at the time of pulverization. Make at least one measurement for each 3000-square yard of work done and record the measurements to ensure that the specified milling depth is met. Correct or satisfactorily replace any section deficient 1/2 inch or more from the specified depth.
E. Compaction. Shape, grade, and compact to the lines, grades, and depth shown on the plans and cross sections after the material has been processed. Maintain material to within ±3% optimum and the optimum moisture content at the time of compaction. Commence rolling at the low side of the course. Leave 3-6 inches from any unsupported edge(s) unrolled initially to prevent distortion.

Determine in-place density requirements by the construction of at least one control strip under the guidance of a nuclear gauge operator. After each pass of the compaction equipment, take a nuclear density reading in accordance with PTM No. 402. Continue compaction with each piece of equipment until no appreciable increase in density is obtained by additional passes. Upon completion of compaction, make a minimum of ten tests at random locations to determine the average in-place density of the control strip. Record and provide results to the Municipality.

Compact the bituminous stabilized base course to a target density of at least 98% of the average in-place density of the control strip. Determine the in-place density in accordance with PTM No. 402 for each 3000 square yard area. If the density of an area is less than the minimum density, but the base course is uniform in texture, stable, and otherwise acceptable, try additional compaction. If additional compaction does not achieve the minimum density, complete an additional control strip in order to verify that proper density is being obtained. Take a minimum of five tests at random locations to determine the average in-place density of the control strip. The new minimum density is 98% of the average in-place density.

If it is determined that the contractor is achieving the target density with minimum compactive effort, the Inspector may require a new control strip to verify or establish a new target density.

If the completed bituminous stabilized base course is unacceptable for any reason, do not continue construction until the cause of the deficiency (ies) is determined.

F. Finishing. Complete all portions of the bituminous stabilized base course during daylight hours, unless otherwise allowed.

G. Protection. Protect any finished portion of the bituminous stabilized base course upon which any construction equipment is required to travel to prevent marring, distortion or damage of any kind. Immediately and satisfactorily correct any such damage.

H. Surface Tolerance. When directed by the Inspector, test the completed bituminous stabilized base course for smoothness and accuracy of grade, both transversely and longitudinally using suitable templates and straightedges. Satisfactorily correct any 3000 square yard area where the average surface irregularity exceeds 1/2 in. under a template or straightedge, based on a minimum of at least three measurements.

I. Curing. Do not allow traffic on the newly constructed bituminous stabilized base course until it cures unless otherwise directed in writing by the Municipality. Allow the bituminous stabilized base course to cure for at least 5 days after final compaction has been completed. If excessive raveling is present, apply a bituminous prime coat over the affected area. The rate of application for bituminous material will be up to 0.21 gallons per square yard). The bituminous material will be emulsified asphalt meeting the requirements of Publication 408, Section 461.2(a). Final surfacing will not take place until the stabilized material moisture content is within 2% of the pulverized pavement in-situ moisture content.

IV. MEASUREMENT AND PAYMENT —

A. Bituminous Stabilized Base. Square Yard.

B. Aggregate. Ton.


D. Bituminous Prime Coat. Square Yard or Gallon.
Section 400

Incidental Construction and Materials
Small Diameter Pipe

I. DESCRIPTION — This work is construction or reconstruction and cleaning of 6 inch to 18 inch diameter pipe culverts, and storm drains; including the direct design, manufacturing and testing of reinforced concrete.

II. MATERIAL —

A. Pipes. Publication 408, Section 601 and Comply with the following:

1. Certification. MS-447A
2. Size and Type of Pipe. As indicated.
3. Reinforced Concrete (RC) Pipe, Metal Pipe, Thermoplastic Pipes.

3.a Round and Reinforced Concrete Pipe. Provide RC pipe in accordance to BD-636M, (BD-636), Appendix H of PENNDOT Design Manual Part 4M (Part 4) and the Pennsylvania Installation Direct Design (PAIDD) computer program.

III. CONSTRUCTION — As shown on the Standard Drawings and as follows:

A. General. Provide 6 inch minimum cover from subgrade to pipe barrel. Construct the embankment to 4 feet above the top of pipe elevation or to subgrade, whichever is less, before excavating for the pipe. Hauling will not be permitted over pipe with less than 4 feet of cover. Where running water is encountered and cannot be diverted, provide an acceptable temporary pipe or other structure prior to placing embankment, or as otherwise directed.

Cover Requirements. Pipes with cover between 6 inches and 12 inches must be approved by a registered professional engineer or a PENNDOT engineer knowledgeable in drainage design. Pipes with cover greater than 12 inches measured from top of pipe to top of rigid pavement or to bottom of flexible pavement shall be designed in accordance with the governing material specification.

Reinforced Concrete Pipe. A cover of 12 inches shall be the minimum for Reinforced Concrete Pipe.

Ductile Iron Pipe. Ductile Iron Pipe with cover measuring between 12 inches and 30 inches shall be approved by an engineer prior to installation. Ductile Iron Pipe Research Association (DIPRA) PUBLICATION Truck Loads on Pipes Buried at Shallow Depths may be used as a supplement to AWWA C150 when designing pipes for cover between 12 inches and 30 inches. Corrugated Metal Pipe. A cover of 12 inches shall be the minimum for Corrugated Metal Pipes.

B. Trench and Bedding. Excavate trench and construct bedding as shown on the Standard Drawings.

C. Laying Pipe. Lay pipe as shown on the Standard Drawings before constructing base course or pavement. Lay pipe with bells or grooves up grade. Begin placement of the pipe at the outlet end and continue towards the inlet end, unless otherwise directed.

Control the pipe alignment and grade with suitable string lines, with an electronic laser beam system, or by other acceptable methods.

Camber the grade line to offset anticipated settlement due to the height of embankment and bedding used, if directed.

Lay pipe, except interlocking style and pipe joined with bands, with mortared joints. Before placing succeeding pipe sections, place mortar or an approved joint material on the lower half of the joint, to bring the inner surface of the abutting pipe flush with the previously placed section, such that the flow of water is not obstructed in any manner. Before placing mortar, wet the pipe with as much water as it will readily absorb. Fill the outside of bell and spigot pipe joints with mortar flush with the bell end. Fill tongue-and-groove pipe joints flush with the pipe's outside surface. On the inside of the pipe, fill the lower half of the joint flush with mortar. Backfilling may proceed immediately after mortaring joints, provided the operation does not cause joint damage, maintains pipe in proper alignment and grade, and provides satisfactory curing conditions for
mortar. When permitted, either a preformed joint or caulking compound of an acceptable type may be used in place of mortar to join pipe sections.

On straight-line pipe placements, join pipe sections within 3/4 inch per foot of inside diameter or 1 inch, whichever is less. Join pipes placed on a radius to within these tolerances as measured at a point halfway up the pipe, string line, along the interior of the curve. For pipe runs placed on curves with a radius less than 765 yards (greater than 2 degrees, 30 minutes) use shorter lengths of precast pipe to minimize the joint gap.

When pipes are protected by endwalls or connected with drainage structures, place exposed pipe end within cast-in-place wall or cut off flush with precast structure face and finish with mortar, as directed. Provide satisfactory connections to existing drainage structures.

Coat all aluminum surfaces that will be embedded into concrete with one coat of zinc chromate primer, or a coat of bituminous paint. Allow coating to dry completely before placement of concrete.

D. Elongation of Metal Pipes. When indicated, elongate metal pipe vertically 5%, using acceptable shop methods. Elongate coated pipe by acceptable shop methods only. Satisfactorily repair coating damaged by elongation procedures.

E. Backfilling Trench. After the pipe is laid, backfill the trench as shown on the Standard Drawings. Place material in 4 inch layers. However, 8 inch layers will be permitted when using vibratory compaction equipment. Compact each layer of backfill to the density shown on the Standard Drawings to a height of 4 feet above the top of the pipe, for the full trench width. Use mechanical tampers or other acceptable compaction equipment that will not damage the pipe. Compact backfill material to the density shown on the Standard Drawing as determined by Standard Proctor Density (SPD). Test as specified in Publication 408, Section 600. Test the coarse aggregate backfill for reinforced concrete pipe before placing remaining backfill.

F. Shored or Trench Box Installation. Construct shored or trench box installation where indicated and as specified in Publication 408, Section 107.08. Construct shored or trench box installation as required for reinforced concrete pipe.

Construct shored or trench box installations for thermoplastic or metal pipe as follows:

1. Unless otherwise directed by the Engineer leave trench sheeting in place to prevent loss of foundation support and backfill materials. When the top of trench sheeting is to be cut off, make the cut 18 inches or more above the crown of the pipe. Leave rangers, whalers, and braces in place as required to support the cut off sheeting and trench wall in the vicinity of the pipe zone. Leave timber sheeting in place. Treat timber sheeting against biological degradation and decay if placed above the ground water table.

2. Do not disturb the installed pipe and its embedment when using movable trench boxes and shields. Do not use movable supports below the top of the pipe backfill pay limit zone unless approved methods for maintaining the integrity and level of compaction of the backfill material are used. Before moving supports, place and compact embedment to sufficient depths to ensure protection of the pipe. Finish placing and compacting the backfill material as supports are moved.

3. If the use of sheeting or other trench wall supports is permitted below the pipe backfill pay limit zone, ensure that pipe, bedding, and backfill materials are not disturbed by support removal. Fill voids left upon removal of supports and compact all material to required densities.
G. **Jacked Pipe.** Jack pipe by means of conventional tunneling or boring methods, when indicated. Before commencement of this work, submit a complete plan and schedule for pipe installation. Include complete details of sheeting, shoring, and bracing for the protection of facilities above the pipe, as well as materials and equipment pertinent to the jacking operation. Do not proceed with pipe installation until the plan and schedule are accepted.

Do not disturb facilities or cause settlement of the ground above the pipe. Provide free and unobstructed use of facilities above the pipe, without delay or danger to life, equipment, or property. Install pipe immediately following the heading or tunneling excavation. After completion of the jacking operation, fill voids around the pipe with grout placed under pressure. Properly protect the grout for at least 3 days.

Place joint sealant material on concrete pipe in front of the jacking frame. Replace or repair pipe damaged during the jacking operations as directed. If steel casing pipe is used, butt-weld the joints as installation progresses. Make joints watertight.

If it is determined that the pipe installation is being conducted in an unsatisfactory manner, stop this work and place a bulkhead at the heading until an alternate procedure is proposed and accepted.

H. **Extension of Existing Pipe.** If extensions of pipe culverts or drains are indicated or required, remove the existing endwalls as directed. Cut the existing pipe to a true edge, as required, to make a satisfactory joint. Join the new pipe to the existing pipe or endwalls, using acceptable collars constructed of Class A Concrete or acceptable metal connecting bands. Clean the existing pipe, as specified in Publication 408, Section 600-697. Repair or replace existing pipe damaged during construction.

As an alternate to removing the endwall, if permitted, extend the pipe using a concrete collar for pipe extension, as specified in Publication 408, Section 600-697.

I. **Cleaning Existing Pipes.** Clean existing pipe culverts, as indicated and as directed, before the start of roadway paving operations. Clean inlets, bridge scuppers and piping, manholes, endwalls, and other drainage appurtenances connected to the pipes, as directed. Clean in an acceptable manner and repair damage resulting from the cleaning operation. Remove any material deposited in inlets during paving operations. Prevent material cleaned from the drainage system from entering streams or other bodies of water, and dispose of this material in a satisfactory manner.

J. **Relaid Pipe.** Remove and clean existing pipes as indicated, and have them inspected by the Representative. Transport and relay accepted existing pipes at the indicated locations, in the same manner specified for new pipes.

K. **Removal and Replacement.** Remove and replace pipe that is not true to alignment, shows settlement after installation, or is broken or damaged.

L. **Inspection of Pipes.** Before final acceptance, inspect all of the following types of installed pipe with total load applied. Inspect 18 inch to 30 inch diameter pipes from access points. Provide written documentation of all inspections to the Engineer within 72 hours following each inspection.

1. **Concrete Pipes.** Inspect concrete pipes for signs of damage including cracks greater than 0.007 inch in width, spalls, damaged or cracked ends, and visible reinforcement. Submit a plan for repair or replacement as specified in Publication 408, Section 600-697 for approval.

2. **Metal Pipes.** Inspect metal pipes for damage including rust, cracking of coatings, damaged galvanization or lining, loose bolts, and areas of local buckling. Repair damaged coatings according to AASHTO M 36/M 36M and AASHTO M 245/M 245M. Develop a repair or replacement plan as specified in Publication 408, Section 600-697 for damage repairs not covered by AASHTO M 36/M 36M or AASHTO M 245/M 245M, buckling, or other major damage, and submit it for approval.
3. **Thermoplastic Pipes.** Inspect thermoplastic pipes for cracking and joint separation, and perform deflection testing at least 30 days after the embankment is completed. Perform the deflection testing using either electronic deflectometers, calibrated television or video cameras, properly sized “go, no-go” mandrel, direct measurement by extension rulers or tape measures in pipes that allow safe entry, or other acceptable devices. Where pipe cannot be physically inspected, perform deflection testing at a minimum. Where deflection is greater than 5% of the unloaded inside diameter of the pipe, or cracking or joint separation is detected, develop a remediation plan in accordance with Publication 408, Section 600-697 and submit it to the Engineer for approval.

M. **Remediation.** Remedial action may include but is not limited to removal and replacement or an accepted repair procedure.

IV. **MEASUREMENT AND PAYMENT —**

A. **Pipe Culverts and Relaid Pipe Culverts.** Linear Foot Measured to the point of centerline intersection of “T,” “Y,” and other branches. Includes the pipe, the bedding material, and the backfill as shown on the Standard Drawings.

Furnishing personnel and equipment for dewatering operations, inspection of pipes, and all remedial measures will be considered incidental to the pipe items.

When the pipe item for shore/trench box is indicated or required; includes placement and removal or keeping in place of shoring, supports, shield systems and trench boxes as specified in Publication 408, Section 600-697.

B. **Cement Concrete for Miscellaneous Drainage.** Cubic Yard As indicated, for the class specified, for the item indicated. Includes reinforcement when required.

C. **Class 1 Excavation.** Cubic Yard. Pay limits as shown on the Standard Drawings.

D. **Class 2 Excavation.** Cubic Yard. Including bedding and anchors.

E. **Class 4 Excavation.** Cubic Yard

Pay limits as shown on the Standard Drawing for pipe culverts and re-laid pipe culverts. Where inlets are installed, measurement terminates 1 foot from the outside face of the inlet wall.

F. **Cleaning Existing Pipe Culverts.** Linear Foot Measured from inlets, endwalls, and other drainage appurtenances along the pipe centerline.

Cleaning of pipe culverts having diameters up to and including 36 inches will be paid for under one pay item.

G. **Jacked Pipe.** Linear Foot. The unit price includes excavation.
I. DESCRIPTION-This work is the installation of storm sewer drainage structures-drains.

II. MATERIAL- As shown on the Standard Drawing or manufacturer's specification and as follows:

A. Storm Sewer Drain Body. PVC. Provide storm sewer drains from PVC pipe stock using a thermo-molding process to reform the pipe stock to the specified configuration. Form storm sewer drains to provide a watertight connection with the specified pipe system. Meet the mechanical property requirements for PVC described by ASTM D3034.

B. Pipe Connection Stubs. PVC pipe stock. Provide a watertight connection with the specified pipe system. Conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals. Meet the mechanical property requirements for fabricated fittings described by ASTM D3034 and ASTM F1336.

C. Certification. Certify materials as specified in Publication 408, Section 106.03(b) 3.

D. Size. 200 to 760 mm (8 to 30 inch), adapts to pipe sizes 100 to 760 mm (4 to 30 inch). Use sizes indicated on contract drawing and referenced within the contract specifications.

E. Class AA Cement Concrete. Publication 408, Section 704.

F. Coarse Aggregate. Type Cor better, Publication 408, Section 703.2

G. Miscellaneous Materials
   1. Ductile iron grates. ASTM A536 grade 70-50-05.
   2. Rubber gaskets. ASTM F477.

III. CONSTRUCTION- As shown on the Standard Drawing or manufacturer's specification and as follows, in accordance with ASTM D2321:

A. General. Install the storm sewer drain using conventional flexible pipe backfill materials and procedures.

B. Installation. As indicated in Standard Drawing, using connection tee and riser pipe, or PVC drainage structure as recommended by manufacturer. Excavate storm sewer drain location to depth of connection pipe. Install connection tee and riser using joint method specified for the pipe system. Use an ASTM F-477 gasket on top end of riser pipe to make watertight connection to the storm sewer drain. For corrugated pipe place gasket into last corrugation of the pipe. Lubricate storm sewer drain bell and pipe gasket. Push pipe into the drain structure to the seat position. Verify drain depth, level and position; correct as necessary. Backfill the open volume surrounding the storm sewer drain with coarse aggregate. Backfill evenly in 200 mm (8 inch) lifts and compact in accordance with ASTM D2321.

Cut top of riser pipe if required to set top of storm sewer drain to final grade elevation to maintain a one piece leak-proof structure.

For load rated installations, a concrete slab shall be poured under and around the grate and frame. The concrete slab must be designed taking into consideration local soil conditions, traffic loading, and other applicable design factors.

For H-25 load rated installations pour a 200 mm (8 inch) thick concrete ring under the grate and frame as recommended on details provided by the manufacturer.

IV. MEASUREMENT AND PAYMENT-

A. PVC Storm Sewer Drain including Rubber Gasket and Ductile Iron Frame and Grate. Each piece.

B. Cement Concrete for Miscellaneous Drainage. Cubic Meter (Cubic Yard). As indicated, for the class specified, and item indicated.

C. Coarse Aggregate. Square Meter (Square Yard).
I. DESCRIPTION — This work is the installation of storm sewer drainage structures—drain basins.

II. MATERIAL — As shown on the Standard Drawing or manufacturer's specification and as follows:

A. Storm Sewer Drain Basin Body. PVC. Provide storm sewer drain basins from PVC pipe stock using a thermo-molding process to reform the pipe stock to the specified configuration. Form storm sewer drain basins to provide a watertight connection with the specified pipe system.

B. Pipe Connection Stubs. PVC pipe stock. Form connection stubs to provide a watertight connection with the specified pipe system. Conform to ASTM D3212 for joint tightness for drain and sewer plastic pipe using flexible elastomeric seals. Meet mechanical property requirements for fabricated fittings described by ASTM D3034 and ASTM F1336 for pipe bell spigot. Use adapter fitting provided by the basin manufacturer for pipe connections to existing pvc basins.

C. Certification. Materials certified as specified in Publication 408, Section 106.03(b)3.

D. Size. 8 to 30 inch adapts to pipe sizes 4 to 30 inch. Use size indicated on contract drawing and referenced within contract specifications.

E. Class AA Cement Concrete. Publication 408, Section 704.2.

F. Coarse Aggregate. Type C or better, Publication 408, Section 703.2

G. Miscellaneous Materials.
   1. Ductile iron grates meeting ASTM A536 grade 70-50-05, 12 inch and 15 inch cast iron frames and ASTM F477 rubber gaskets for watertight water connection to riser pipe – both material types provided by manufacturer. The grates for storm sewer drain basins are ductile iron grates for basin diameters 8, 10, 12, 15, 18, 28, and 30 inch are made specifically for each basin by the manufacturer to provide a round bottom flange that closely matches the diameter of the storm sewer drain basin
   2. Provide grates for storm sewer drain basins capable of supporting H-25 wheel loading for heavy-duty traffic or H-10 loading for pedestrian traffic. Hinge 12 inch and 15 inch grates to the frame using pins.

III. CONSTRUCTION —

A. General. Install the PVC storm sewer drain basin using conventional flexible pipe backfill materials and procedures.

B. Installation. Excavate storm sewer drain basin location to depth and place a 6 inch base of crushed stone or other granular material. Set storm sewer drain basin in place and level. Install ASTM F-477 gasket on end of pipe. For corrugated pipe, place gasket into last corrugation of the pipe. Lubricate the storm sewer drain basin bell pipe gasket. Push pipe into the drain basin structure to the seat position. Verify drain basin depth, level and position; correct if necessary. Backfill the open volume surrounding the drain basin with coarse aggregate. Backfill evenly in 8 inch lifts and compact each lift to 90-95% of maximum density in accordance with ASTM D2321. Adjust to final grade elevation by either cutting the drain basin body to required grade or by adding PVC Riser Extensions as provided by the manufacturer. For H-25 load rated installations, pour a 8 to 10 inch thick concrete ring under the grate and frame as recommended on details provided by the manufacturer.
IV. MEASUREMENT AND PAYMENT —

A. PVC Basin. Vertical Foot per each diameter.

B. Cement Concrete for Miscellaneous Drainage. Cubic Yard. As indicated, for the class specified, for the item indicated.


D. Frame and Grate. Per Piece. Varies with size.

E. Coarse Aggregate. Square Yard
# PVC BASIN - MINIMUM ANGLE CHART FOR PIPE CONNECTIONS

## 8” Diameter Basins

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</table>
### PVC BASIN - MINIMUM ANGLE CHART FOR PIPE CONNECTIONS

#### 24” Diameter Basins

<table>
<thead>
<tr>
<th>Pipe connection Diameters</th>
<th>Inches</th>
<th>Minimum Angle Degrees</th>
</tr>
</thead>
<tbody>
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#### 30” Diameter Basins

<table>
<thead>
<tr>
<th>Pipe connection Diameters</th>
<th>Inches</th>
<th>Minimum Angle Degrees</th>
</tr>
</thead>
<tbody>
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<td>30</td>
<td>115</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>150</td>
</tr>
</tbody>
</table>
I. DESCRIPTION — This work is the placement of dust palliatives as a surface treatment on existing unpaved roadways or on roadways improved by grading or scarifying to a maximum of 1 inch depth.

II. MATERIAL — As shown on the Standard Drawing or manufacturers specification and as follows:

1. Calcium Lignosulfonate

2. Non-Bituminous Emulsified Petroleum Resins (EPR)

3. Petroleum Emulsion Dust Suppressants

4. Acrylic Polymer Dust Suppressant

5. Non-Asphalt Plant Based Emulsion


7. Soil Stabilizer

(1) Calcium Lignosulfonate Residue: Provide calcium as the base chemical. Supply lignin sulfonate as a water solution.

   a. The calcium lignosulfonate (neat material) shall be homogeneous, shall be mixable with water in all proportions and show no separation after thorough mixing within 30 days after delivery.

   b. Diluted calcium lignosulfonate held in storage tanks for periods longer than 24 hours shall be agitated, sampled and retested to determine compliance with specification requirements.

   c. Each application of this material shall be a minimum of two (2) passes on a prepared surface. For each pass, apply at a rate of 0.5 gallons per square yard, at a dilution ratio of 1:1 (neat material to water). Dependent upon road conditions and recommendation of the supplier this application rate may vary. This material shall be shipped at the dilution ratio specified for each location such that it can be used within a 24-hour period. The vendor shall properly prepare the roads by blading, grading and compacting prior to the initial application. Additional reaplication may be necessary at a 4 to 8 week interval dependent upon road conditions, material, or as required by the manufacturer. Blading and grading of the road surface is not necessary prior to reaplication.

<table>
<thead>
<tr>
<th></th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (AASHTO T 200) (Neat Material)</td>
<td>4.5</td>
<td>-</td>
</tr>
<tr>
<td>Viscosity, (AASHTO T 202) at 25C (77F), sec. (Neat Material)</td>
<td>-</td>
<td>20.5</td>
</tr>
<tr>
<td>Percent Total Solids (TAPPI- T 629-M 53) (Neat Material)</td>
<td>50</td>
<td>-</td>
</tr>
<tr>
<td>Sand Penetration Test and Cure Test (Appendix C, Bulletin 25) (Diluted material)</td>
<td>Pass</td>
<td></td>
</tr>
</tbody>
</table>

All samples shall be shipped and stored in clean airtight sealed wide mouth jars or bottles made of plastic.
d. The temperature of the material from the time it is loaded until it is applied on the road shall not exceed 140°F. The temperature of the material at application shall be between 40°F and 140°F.

e. The specific gravity of the calcium lignosulfonate (neat material) shall be reported for each shipment and shall also meet the following requirements:

(2) Non-Bituminous Emulsified Petroleum Resin (EPR)

a. The emulsified petroleum resin (neat material) shall be homogeneous, shall be mixable with water in all proportions and show no separation within 30 days after delivery.

b. Diluted emulsified petroleum resins held in storage tanks for periods longer than 24 hours shall be agitated, sampled and retested to determine compliance with specification requirements.

c. Each application of this material shall be a minimum of two (2) passes on a prepared surface. For each pass, apply at a rate of 0.20 gallons per square yard, at a dilution ratio of 1:3 to 1:4 (neat material to water). Dependent upon road conditions and recommendation of the supplier this application rate may vary. This material shall be shipped at the dilution ratio specified for each location such that it can be used within a 24-hour period. The vendor shall properly prepare the roads by blading, grading and compacting prior to the initial application. Additional reapplication may be necessary at a 4 to 8 week interval dependent upon road conditions, material, or as required by the manufacturer. Blading and grading of the road surface is not necessary prior to reapplication.

d. The specific gravity of the emulsified petroleum resins (neat material) shall be reported for each shipment and shall also meet the following requirements:

<table>
<thead>
<tr>
<th>Test</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity, Saybolt Furol at 77°F, sec. (neat material)</td>
<td>-</td>
<td>75</td>
</tr>
<tr>
<td>Sieve Test; (2) Sieve Percent retained (neat material)</td>
<td>-</td>
<td>0.10</td>
</tr>
<tr>
<td>Distillation: Residue, percent by mass (neat material)</td>
<td>50</td>
<td>65</td>
</tr>
<tr>
<td>Sand penetration test and cure test (Appendix C, Bulletin 25) (diluted material)</td>
<td>Pass</td>
<td></td>
</tr>
</tbody>
</table>

All samples shall be shipped and stored in clean airtight sealed wide mouth jars or bottles made of plastic.

(3) Petroleum Emulsion and Acrylic Polymer Dust Suppressant application rates.

<table>
<thead>
<tr>
<th>Product name</th>
<th>Approved Application Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penn Suppress “D”</td>
<td>1:4 emulsion to water or more dilute</td>
</tr>
<tr>
<td>Ultrabond 2000</td>
<td>1:4 emulsion to water or more dilute</td>
</tr>
<tr>
<td>Coherex</td>
<td>1:10 emulsion to water or more dilute</td>
</tr>
<tr>
<td>Dust Bond</td>
<td>1:10 emulsion to water or more dilute</td>
</tr>
<tr>
<td>Pave-Cyrl Suppress</td>
<td>As-received [51% solids]</td>
</tr>
<tr>
<td>Pave-Cyrl Suppress Plus</td>
<td>As-received [51% solids]</td>
</tr>
<tr>
<td>DirtGlue</td>
<td>As-received [&gt;51% solids]</td>
</tr>
</tbody>
</table>
(4) Acrylic Polymer Dust Suppressant

DustREADY 49 Acrylic Polymer 1:4 dilution of product to water. Two applications of 0.25 gal/yd²

(5) Non-Asphalt Plant Based Emulsion. DustClear-G

Material: the material is a non-asphalt and plant based emulsion, diluted and shipped ready to use.

The temperature of the material from the time it is loaded until it is applied on the roadway shall not exceed 140 degrees F. The temperature of the material at the time of application shall be between 40 degrees F and 140 degrees F. It shall be agitated and recirculated with heat before use at a temperature not to exceed 140 degrees F.

The DustClear –G emulsion shall meet the following requirements:

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard</th>
<th>Specification Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve, No.20, maximum %</td>
<td>AASHTO T59</td>
<td>0.1</td>
</tr>
<tr>
<td>Saybolt Furol seconds, 25 degrees C, maximum</td>
<td>AASHTO T59</td>
<td>75</td>
</tr>
<tr>
<td>Residue, minimum, %</td>
<td>AASHTO T59</td>
<td>10</td>
</tr>
<tr>
<td>Sand penetration, Test and Cure Test</td>
<td>Appendix C, Bulletin 25</td>
<td>Pass</td>
</tr>
</tbody>
</table>

Application of DustClear-G Material

1. The roadway may be graded or scarified to a maximum of one inch.

2. The material shall be applied in one or two passes on the prepared surface. For any pass, apply at a rate that does not run off the road. The total applied is typically 0.1 to 0.5 gallons per square yard, depending on the characteristics and openness of the material. Refer to the manufacturer for recommendations.

3. Apply the material when the air temperature is 40 degrees F and rising there is NO threat of rain.

4. Use a distributor conforming to Pub 408, Sec 460.3 (b)

5. Additional application, if needed after 6 to 8 weeks, is dependent on road conditions, material or as recommended.

6. Synthetic Fluid Dust Suppressant. EK 35 ad Envirokleen. Approved application rate, 0.125 gallon/square yard. Two passes are required for a total application rate of 0.250 gallon/square yard. No Dilution.

7. A. Roadbond EN1. A soil stabilizer which will strengthen dirt roads and assist with dust control. Is a Sulfuric Acid based product which requires special handling. Diluted with water at a ratio of not <100 to 1 or >300 to 1 evenly distributed over intended area.

   B. EcoRoads. Enzyme type Soil Stabilizer. Diluted with water at a ratio of 250 to 1, evenly mixed with subgrade to optimum moisture.

III. CONSTRUCTION —

A. Maintenance of Roadway Surfaces.

1. Treat existing earth, gravel, or improved roads with approved dust control palliatives, as specified in the proposal or as directed.

2. The roadway may be graded or scarified to a maximum depth of one inch.
3. Place material to manufacturer’s specifications

4. Form roadbed to the established grade elevation and compact to proper density, using equipment specified in PUBLICATION 408, Section 108.05(c) 3.a, 3.b, 3.e, or 4.

5. When unable to obtain the specified stability, excavate material in the area to a depth that, when replaced and recompacted with a moisture content not exceeding optimum, the roadway will have required stability.

IV. MEASUREMENT AND PAYMENT —Square Yard / Gallon
Anti-skid material for Municipal use.

a. General. For use on ice and snow-covered pavement surfaces, furnish municipal anti-skid conforming to Table A from a supplier listed in Publication 447. Do not use material containing metal, glass or substances that may be harmful to automotive equipment and vehicles. Use material reasonably free of deleterious substances or foreign material including but not limited to dirt, shale slate, and incinerated bituminous coal mine waste and as specified in Section 703.2 (a) of Pub 408 Table B Type C.

b. Description.

1. Types 1 and 1A.
   Cinders, coke, crushed coal boiler bottom ash, or a combination of these. Bottom ash is residue of molten ash obtained from coal-burning boilers.
   a. Furnish bottom ash having no pyritic material or mill rejects commingled, mixed, or combined with it.
   b. Furnish Type 1 anti-skid material conforming to the following requirements:
      • An air dry loose density (weight) of not less than (35 pounds per cubic foot). Determined according to AASHTO T 19, Section 7;
      • Type 1, having a density (unit weight) of (76 pounds per cubic foot) of Type 1A having a density (unit weight) of more than (76 pounds per cubic foot);
      • Crushed Brick, crushed stone, blast furnace slag, steel slag or gravel may be present in amounts not exceeding a total of 3% by mass (weight) of total dry mass (weight) of the sample determined by the mass (weight) of this material retained on the ½ inch sieve.
      • Unburned or partially burned coal or coke may be present in amounts not exceeding 7% by mass (weight) of the total dry mass (weight) of the sample, determined by the mass (weight) of the material retained on the 3/8-inch sieve, except unburned coal, partially burned coal or coke may not be present in bottom ash.

2. Type 4.
   Burned anthracite coal mine refuse with a Los Angeles Abrasion loss not exceeding 55% by mass (weight) determined according to AASHTO T 96.

3. Gradations. Conforming to Table A.

<table>
<thead>
<tr>
<th>Type</th>
<th>1 1/4”</th>
<th>3/4”</th>
<th>1/2”</th>
<th>3/8”</th>
<th>No. 4</th>
<th>No. 8</th>
<th>No. 50</th>
<th>No. 100</th>
<th>No. 200</th>
</tr>
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<tbody>
<tr>
<td>Type 1</td>
<td>100</td>
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<td></td>
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<td>70</td>
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<td>Type 1A</td>
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<td>90-100</td>
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<td>18</td>
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<tr>
<td>Type 4</td>
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<td>95-100</td>
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<td>8</td>
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<td></td>
</tr>
</tbody>
</table>

Current approved Suppliers: (August 18, 2014)

1. Ash Resources, Inc., 401 Route 61 South, P.O. Box 559, Schuylkill Haven, PA 17972
   Producing site: Montour Co., Washingtonville
2. Lloyd Aggregates, Inc., 521 Foote Ave., New Milford, PA 18834
   Producing site: Lackawanna Co., Dickson City, PA
3. Mineral Reclamation LLC., P.O. Box 866, Pittston, PA 18640
   Production Site: Luzerne Co., Hanover Township
4. Valley Stone Quarry, 202 Main Street, Laflin, PA 18702
   Production sites: Lackawanna Co., Mayfield/Luzerne Co., Plains Township
5. Waste Management Processors, P.O. Box K, Frackville, PA 17931
   Production Site: Schuylkill Co., Frackville
6. Talen Energy, Brunner Island Plant, 1400 Wago Road, York Haven, PA 17370
7. McClure Enterprises Inc., P.O. Box 3775 Scranton, Pa 18505. Stockpile Location, Rear East Brady Street West Wyoming, PA 18644

Certification: Certify using Municipal Services form MS-447A.
Driving Surface Aggregate (DSA) and Material Requirements

I. DESCRIPTION — This work is the construction of Driving Surface Aggregate. When placed on subgrade, this work includes the preparation of subgrade as specified in Publication 408, Section 210.

II. MATERIAL — Obtain Material from a source listed in Bulletin 14 if using liquid fuels monies.

A. Certification. Certification. MS-447A

B. Aggregate. Publication 408, Section 703 and as follows:

<table>
<thead>
<tr>
<th>PASSING SIEVE</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5 mm (1½ Inch)</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>19 mm (¾ Inch)</td>
<td>65%</td>
<td>95%</td>
</tr>
<tr>
<td>4.75 mm (#4)</td>
<td>30%</td>
<td>65%</td>
</tr>
<tr>
<td>1.18 mm (#16)</td>
<td>15%</td>
<td>30%</td>
</tr>
<tr>
<td>75 µm (#200)</td>
<td>10%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Quality Control
Determine the resistance to degradation using the Los Angeles Abrasion test, AASHTO T-96 (ASTM C 131). The loss of mass shall be less than 40%. Existing tests made for and approved by PennDOT will be accepted. Testing will be performed by an independent lab at the owner’s expense.

Aggregate will be within the range of pH 6 – pH 12.45 as measured by EPA 9045C. Testing will be performed by an independent lab at the owner’s expense.

Derive 95% of the aggregate mix from the crushing of clean rock material. If 10% of the aggregate mix does not pass the #200 sieve, utilize up to 5% external source material approved by the engineer to the mix. Do not add clay or silt. Determine the amount of particles less than # 200 sieve size by using the washing procedures specified in PTM No. 100. Lime kiln Dust and cement Kiln Dust may be added to DSA to account for up to 50% of the fines passing the #200 sieve.

III. CONSTRUCTION —

A. Equipment: Spreaders. Publication 408, Section 320.3(a)3, Paver preferred

Compaction Equipment. Publication 408, Section 108.05(c) 3.a, 3.b, 3.e, 4.

B. General. Prepare the subgrade as specified in Publication 408, Section 210 and as follows, before placing (DSA). Do not place (DSA) material on soft, muddy, or frozen areas.

Correct unsatisfactory subgrade conditions developing ahead of the paving operations by scarifying, reshaping, and recompacting, or by replacing the subgrade. The subgrade must be crowned to ½ to ¾ inch per foot, flat “A” cross profile. This may be precluded by the absence of sufficient material such as occurs when bedrock is exposed.

When required, evenly place separation fabric according to manufacturer’s recommendations, after scarification.

C. Mixing. Use acceptable methods to mix (DSA) and water to obtain optimum moisture content for the mix as determined by PTM No. 106 before delivery to the project. Use material containing optimum moisture to prevent segregation during stockpiling, hauling, placing, and to minimize water added during compaction. Maintain (DSA) aggregate at optimum moisture from before placement to compaction. AASHTO T-99, ASTM D698, or PA Test Method No. 106.

D. Transport. Use tarpers to cover 100% of the load’s exposed surface from the time of loading until immediately before placement.
E. **Placement.** Place the (DSA) on the subgrade using a paver without causing segregation.

Place (DSA) to a minimum un-compacted depth of 6 inches and a maximum un-compacted depth of 8 inches in one lift. The crown or side slope must range from ½ to ¾ inch per foot, for road widths up to 20 feet.

Material is to be be delivered and placed at optimum moisture content +/- 1% as determined for that particular source. The optimum percentage moisture is to be determined using Proctor Test ASTM D698, procedure C, standard.

F. **Compaction.** Compaction and Density. Compact DSA to between 95% and 100% of the maximum dry-mass (dry-weight) density, determined according to PTM No. 106, Method B. At locations directed by the owner, determine the in-place density for each 2500 m² (3,000 square yards), of each layer according to AASHTO T 191 or T 310.

Beginning on the lower or berm side of the crown, begin rolling and work to the top of the crown by overlapping the successive longitudinal passes. Utilize static mode on the initial and downgrade passes. Do not run the roller lengthwise directly over the crown. Compact to specified density requirements, using equipment specified is Publication 408, Section 108.05(c) 3.a, 3.b, 3.e, or 4.

G. **Incidental.** To fill driving surface areas outside the specified width, such as driveway entrances, turnouts and wider passing lanes, add additional new DSA material to fill to the same depth specified throughout the project. If berm edges do not exist to hold the fill, then place, taper and compact sufficient material to form protective edge berms.


IV. **MEASUREMENT AND PAYMENT** — Ton
I. DESCRIPTION — This work is trenchless pipe rehabilitation (TPR) to improve flow and prevent infiltration for storm drains and culverts in compliance with these specifications, contract documents, installation plan, and Appendix B “General Guidelines for Trenchless Pipe Rehabilitation” (TPR). TPR is to be used where the host pipe or liner pipe is capable of sustaining design and construction loads through review and inspection by a Professional Engineer. Acceptance and verification of all documents are the responsibility of the owner.

II. MATERIAL — If the Engineer determines the host pipe cannot sustain existing loads provide a pipe design with sufficient strength to support all dead loads, live loads and groundwater loads imposed and in compliance with Pennsylvania Publication 15M. Provide a pipe with a minimum thickness of SDR 32.5. Submit design calculations signed and sealed by a professional engineer registered in the Commonwealth of Pennsylvania. Provide a sample installation if required by the owner.

A. General.

1. The outside perimeter of the lining tube before reforming is to be smaller than the inside perimeter of the segment to be lined. The difference is not to exceed 12% for PVC and 3% for PE. The percentage is not to exceed over at least 80% of the length of each section lined. A larger percentage difference is allowed on up to 20% of each segment length to account for all variations in host pipe diameter. The 20% allowance cannot be exceeded in an individual segment being lined. For round facilities the perimeter can be computed as \( p = \pi(D) \) where ID is the measured inside diameter resulting from averaging at least three diameter measurements. Measure the perimeter directly.

2. Provide a liner that is resistant to abrasion caused by solids, grit, and/or sand. Provide a liner that is resistant to corrosion due to acids and gases such as dilute sulfuric acid, carbonic acid, hydrogen sulfide, methane, and carbon monoxide.

3. Provide a liner tested in accordance with ASTM D790 and ASTM D543 before and after conditioning. Reference: Appendix A.

B. High Density Polyethylene (PE) Liner.

1. Deformed. ASTM F1533.


3. Slip Lining Joints. ASTM D3212 (with liner pipe joints that do not increase the pipe O.D. or decrease the pipe I.D.).

C. Polyvinylchloride (PVC)

1. Deformed PVC liner. ASTM F1504, F1697 or F1871.

2. Spiral-wound PVC liner. ASTM F1735.


4. PVC Pipe. ASTM F949, D618.

5. Gaskets. ASTM F447.

6. Slip lining joints. ASTM D3212 (with PVC liner pipe joints that do not increase the pipe O.D. or decrease the pipe I.D.).
D. **Glass Fiber Reinforced Polymer Pipe (FRP)**
   1. **FRP Pipe.** ASTM D3262, 46 psi minimum pipe stiffness.
   2. **Gaskets.** ASTM F477.
   3. **Joints.** ASTM D4161.

E. **Polymer Concrete Pipe.** Use only polyester or vinyl ester resin systems designed for the service intended.
   1. **Aggregate, sand and quartz powder.** ASTM C 33.
   2. **Gaskets.** ASTM F 477.
   3. **Stainless steel joint sleeves/couplings.** ASTM A276.

F. **Cured-in-Place-Pipe (CIPP).** Premium, Non-Recycled resin. ASTM F1216.

G. **Grouting Materials**

   1. Work is to be performed under the guidelines of Appendix A "General Guidelines for Trenchless Pipe Rehabilitation (TPR).
   2. Provide grouts that consist of Portland cement, water, fly ash, and admixtures as recommended by the PVC liner and HDPE liner supplier, suitable for completely filling the annular space and all voids.
   3. Develop mix designs based on the following criteria:
      - Size of the annular void.
      - Sufficient durability to prevent movement of the liner in the pipe.
      - Distance between grout injection ports.
      - Absence or presence of ground water.
      - Pumping time.
      - Less than one percent shrinkage by volume in compliance with ASTM C-1090.
   4. Provide grout having the following properties:
      - Compressive Strength-Minimum of 145 psi in seven days, and a max of 722 psi in 28 days in compliance with ASTM C-942. Provide grout for machine spiral winding having a minimum compressive strength of 3002 psi in 28 days in compliance with ASTM C495 or ASTM C109. Collect and test three samples for each grout lift.
      - Apparent Viscosity-Maximum of 35 seconds in compliance with ASTM C-939, unless otherwise approve.
      - Density. ASTM C138. 1922.4 +~ 80.1 kg/m3.
      - Penetration Resistance-Minimum of 690 Kpa in 24 hours in compliance with ASTM C403.
   5. **Certification.** MS-447A
III. CONSTRUCTION —

A. General Requirements
   1. Work is to be performed under the guidelines of Appendix A “General Guidelines for Trenchless Pipe Rehabilitation (TPR).
   2. Provide an installation plan a minimum of 10 days prior to starting work. Include pipe manufacturer’s instructions, dewatering, assembly drawings, necessary insertion, bracing methods, proposed shotcreting, concrete, deflection tolerances, and void filling methods.
   3. For installations where a direct visual inspection is not possible, perform video inspections and connection reopening (if applicable) using a swivel head camera capable of looking directly up a connection in any nominal line size with service connections to be re-installed in the project. Utilize cutting and trimming equipment capable of performing operations in lines 6" and larger. Demonstrate satisfactory operation, and obtain approval of cameras and other equipment before lining operations begin.
   4. Perform point repairs using PVC SDR-35 pipe and no-hub adapters or by other materials approved by the engineer.

B. Installation
   1. Perform installation of the liner in compliance to the installation procedure described in the Installation Plan. All equipment, labor, materials, and processes required to complete the work must be ready on-site before installation begins.
   2. The first segment completed and accepted is to become the "job standard" against which all subsequent work is judged.
   3. If the pre-installation inspection reveals a sagging joint with less than 90% clearance, take the necessary steps to eliminate the sagging points.
      a. Thermoplastic Folded Pipe
         1. Install High Density Polyethylene by Thermoplastic Folded Pipe technique ASTM F1606.
         2. Install PVC by Thermoplastic Folded Pipe technique ASTM F1947 or ASTM F1867
      b. Grouted Spiral Wound
         1. Install PVC by spiral wound technique ASTM F1698, for manual installation, or ASTM F1741, for mechanized installation.
      c. Expanded Spiral Wound
         1. Install PVC Lining System with an inside diameter not more than 4 inch smaller than the existing pipe to provide for a 2 inch thick cementitious grout seal when complete.
         2. Install PVC by machine-driven spiral-wound technique ASTM F1741.
      d. Cured-in-Place-Pipe
         1. Install CIPP. ASTM F1741, ASTM D638, and ASTM D790.
      e. Glass Fiber Reinforced Polymer Pipe
         1. Install FRP. As per manufacturers recommendations and ASTM D3754-04.

C. Finished Pipe
   1. Provide a finished TPR liner continuous over the entire length of each section lined, and free from visual defects such as foreign inclusions, folds, pinholes and other defects. Service connections or branches are to be reopened and trimmed to a neat, clean opening concentric with the service line pipe. Any defects that are encountered during the warranty period affecting the integrity or strength of the liner pipe or hydraulic capacity are to be repaired at the Contractor’s expense in a manner agreed to by the Owner.

D. Service Reconnection
   1. After the lining process is completed, reconnect the existing line service connections (if any). Reconnect by internal remote cutting method or external excavation.
   2. Ventilate the pipe, monitor the surrounding area, and mitigate any odors that occur due to construction activities.
3. Reopen service connections or branches to 90% service line size (minimum) and trimmed to a neat, clean, circular opening concentric with the service line pipe, free of jagged edges, "saw-teeth," resin plugs or resin shelves.

E. Sealing at Manholes
   1. Make a tight seal at manholes, openings, or abutments with no annular gaps.
   2. Rebuild manholes between liner ends resulting in a smooth, continuous flow-line through the manhole.
   3. Rebuild manholes using epoxy grout or TPR liner material up to bench level. Complete these procedures before proceeding to the next manhole section.

F. Repair of Previously Installed Lines
   1. At locations where access to a previously lined pipe is required, neatly cut to allow for subsequent repair.
   2. Repair the location as described in the Installation Plan and approved by the Owner.
   3. Cover the repaired area with concrete to a minimum thickness of four inches. The repair joint must be approved before covering with concrete.

IV. MEASUREMENT AND PAYMENT —

Polyethylene (PE)-Linear Meter/Foot
Polyvinylchloride (PVC)-Linear Meter/Foot
Glass Fiber Reinforced Polymer Pipe (FRP)-Linear Meter/Foot
Polymer Concrete Pipe-Linear Meter/Foot
Gaskets-Each
Joint sleeves/couplings-Each
Grout-Incidental
Recent concerns from the Virginia Department of Transportation (VDOT) has raised concerns with water quality when CIPP is installed.

Below is a report produced for PennDOT BPR/MRO by the Penn State University’s Thomas D. Larson Pennsylvania Transportation Institute.

We encourage all to be informed of the possible infiltration of less than desirable water from these installations and always use BMP when handling these installations.

1. Introduction

1.1. Background

In 2013, Quality Engineering Solutions (QES) in cooperation with The Pennsylvania State University’s (PSU) Thomas D. Larson Pennsylvania Transportation Institute evaluated section MS-0450-0030 of Pennsylvania Department of Transportation (PennDOT) publication 447 (9-11), "Approved Products for Lower Volume Local Roads," which addresses "Trenchless Pipe Rehabilitation (TPR)".1

In 2014, PennDOT requested the research team to provide a review of documents regarding water quality issues after installation of cured-in-place pipes (CIPP), furnished by the Virginia Department of Transportation (VDOT) and to perhaps contact the manufacturers to get recommendations from them. It was also mentioned that the "measurement and payment" section of MS-0450 -0030 did not include CIPP.

1.2. Objective

The objective of this research was to review literature on water quality issues after CIPP installation (specifically the VDOT documents) and to contact manufacturers/installers and solicit their experiences with the subject.

1.3. Research Approach

In order to achieve the project objectives, a literature review on the subject was carried out, one of the authors of the VDOT reports was contacted for information, and a survey was developed to solicit manufacturers’/installers’ experiences on the subject. These tasks are presented in the following sections.

2. Literature Review

2.1. VDOT Documents

VDOT documents reviewed included two reports, a specification, and a paper. One of the authors of the reports and the paper was contacted as well. The following are summaries of the reviews:

2.1.1. Environmental implications of conventional CIPP are discussed in a report published by VDOT’s Virginia Center for Transportation Innovation and Research (VCTIR).2 In this report, styrene-based resins cured by forced steam were evaluated. The evaluated CIPP installations included surface water and stormwater conveyances and were observed over the course of 1 year. Water samples from five of the seven CIPP installations tested showed detectable levels of styrene. Styrene is classified by the U.S. Environmental Protection Agency (EPA) as a mutagen and is thus potentially carcinogenic. It is also toxic to aquatic species at certain concentrations. Although these sites were not directly linked to drinking water sources, styrene levels were higher than EPA’s maximum contaminant level for drinking water (0.1 mg/L). The styrene concentrations were generally highest in samples collected during and shortly following CIPP installation. Certain measurements were also found to exceed concentrations potentially harmful to freshwater aquatic species.

The report suggests that the higher styrene levels could have resulted from one or a combination of the following:2
• Installation practices that did not capture condensate containing styrene
• Uncured resin that escaped from the liner during installation
• Insufficient curing of the resin
• Some degree of permeability in the lining material

It is reported that VDOT implemented measures to prevent the risks associated with styrene based CIPP technology and to ensure protection of the public health and safety as well as the environment. These measures include substantial modifications to VDOT's CIPP specifications, an inspector training program, increased project oversight, and water and soil testing prior to and after CIPP installation.²

2.1.2. Two unconventional CIPP technologies, namely vinyl ester based (styrene-free) CIPP and styrene-based ultraviolet (UV) CIPP, were evaluated for their effect on water quality in a report published by VDOT’s VCTIR.³ Evaluation methods were similar to the ones utilized in the conventional CIPP report presented above. For the vinyl ester based CIPP, concentrations of the primary resin constituent (vinylic monomer) exceeded toxicity thresholds for aquatic species in six subsequent water sampling events. For the UV CIPP installations, no water quality impacts were documented from culvert outlets with water flow, but styrene concentrations following one of the installations exceeded toxicity thresholds for aquatic species in standing water.

The study recommends that the same safeguard measures for conventional CIPP installations be applied to non-styrene based CIPP installations as well.³

2.1.3. VDOT's "Special Provision for Pipe Rehabilitation"⁴ includes a CIPP rehabilitation method. The CIPP method requirements are largely based on findings of the conventional CIPP study mentioned previously.² Requirements related to water quality are summarized below:⁴

• The Contractor shall place an impermeable sheet immediately upstream and downstream of the host pipe prior to liner insertion to capture any possible raw resin spillage during installation and shall remove and properly dispose of any waste materials.

• The Contractor shall ensure there is no loss of impermeability of the inner and outer plastic films or pre-liner during installation. The Contractor shall promptly repair any pinholes or tears in the plastic films or pre-liner before proceeding with the installation. Where such damaged areas cannot be repaired, the Contractor shall promptly replace the impermeable plastic films or pre-liner before proceeding with the installation.

• The Contractor shall capture and properly dispose of all cure water and/or steam condensate and be responsible for the proper transportation and off-site disposal of process residuals.

• The Contractor shall thoroughly rinse the cured lined pipe with clean water and capture and properly dispose of rinse water prior to re-introducing flow.

• For styrene-based CIPP and vinyl ester-based CIPP, the Contractor shall employ the services of a qualified independent environmental services laboratory or environmental consultant to collect pre-rehabilitation soil and water samples upstream and downstream of the pipe location and the same types of samples within one week after the pipe liner has cured.

• These samples shall be collected in accordance with applicable ASTM standard procedures. For styrene-based liners, samples shall be analyzed for styrene using USEPA SW 846 Method 8260. Styrene concentrations in water samples shall not exceed 2.5 mg/L. For vinyl ester-based liners, samples shall be analyzed for diallyl phthalate. Diallyl phthalate concentrations in water samples shall not exceed 0.4 mg/L.

• It shall be the Contractor’s responsibility to report and take appropriate corrective actions to contain and remediate any release of contaminants from cured-in-place process materials, effluent or condensate into the environment in accordance with applicable local, state, or federal regulations and the Specifications. The cost for such remediation shall be at the Contractor’s expense.

2.1.4. A recent VDOT report presents a standardized test method to quantify environmental impacts of stormwater pipe rehabilitation materials.⁵ CIPP was used as a model in developing the test method.
It is reported that during the project, it was discovered that the material installation process was the main source of environmental pollution, more so than the material." It was also observed that chemicals other than styrene were released by CIPP into stormwater. It is recommended that any further CIPP testing should not be limited to a few contaminants, but be expanded to include other contaminants of environmental and human health concern.

2.1.5. In personal communication with a VDOT research scientist, the above-mentioned information was verified and it was stated that the current VDOT specifications may not be stringent enough. It was also indicated that VDOT will meet soon to discuss how to proceed given the findings from the latest study discussed in 2.1.4. VDOT is also looking into initiating a pooled fund study to conduct additional research on this issue.

2.2. Other Relevant Documents

A search for relevant literature from other states was carried out and resulted in the following list:

2.2.1. A preliminary investigation published by California Department of Transportation's (Caltrans) Division of Research and Innovation discusses environmental effects of CIPP repairs. It is indicated in this document that the North Coast Regional Water Quality Board (NCRWQB) is currently not permitting use of CIPP because of concerns that it negatively affects water quality according to a VDOT study. It mentions that Caltrans, however, has revised its CIPP specifications to take into account lessons learned by Virginia DOT. It is stated that Caltrans is interested in adopting a more scientific approach to the regulatory standards that will allow for continued use of CIPP.

The preliminary investigation presents results of a review of completed research and a survey of state practices addressing the use of CIPP in an environmentally safe manner. A number of references are listed and it is stated that there is no published research available on the environmental impacts of CIPP repairs beyond the original report by the VDOT (reference number 2 in this document). Further, only VDOT has conducted water quality testing on a carefully controlled CIPP installation to evaluate the effectiveness of more stringent specifications. Regarding the survey of state practices, while 11 of 15 survey respondents said they use CIPP, only four states (New York, Oregon, Virginia, and Washington) reported water quality issues (incidents of contamination).

2.2.2. The New York State Department of Transportation (NYSDOT) addresses water quality with regard to CIPP rehabilitation in its Design Guidelines for Rehabilitation of Culvert and Storm Drain Pipe. In the guidelines it is stated that environmental impact concerns and information gathered from the extensive use of CIPP have led to a series of new product developments as well as amendments to installation procedures. Curing water from CIPP installations utilizing a styrene-based resin contains some styrene residual. NYS Water Quality Standards include specific limit guidelines for discharging certain pollutants (including styrene) to various surface water classes and ground water. They dictate that discharges shall not cause impairment of the best usages of the receiving water (as specified by the water classifications) both at the location of discharge or at any other location that may be affected by such discharge.

Provisions for handling and/or disposal alternatives as well as other control procedures are included in the specifications to address the presence of styrene in the curing water and other potential releases to water and air from the byproducts of the CIPP installation. These provisions include:

- Some procedural changes to enhance control of the CIPP process and leakage of resin, including utilizing a pre-liner bag and excavating a temporary resin control pit at the outlet.
- Allowing the use of non-styrene based resins containing less than 5 percent volatile organic compounds (VOCs) with less than 0.1 percent hazardous air pollutants (HAPs).
- In all CIPP installations utilizing a styrene-based resin, it is required to collect the curing water for:
  - Reuse in another curing operation,
  - Treatment or disposal at an off-site facility, or
  - Release on site after treatment to standards dictated by New York State Department of Environmental Conservation (NYSDEC) and with approvals from NYSDEC.

In summary, the resin type alternatives for CIPP work are to either use a non-styrene based resin or follow additional controls when using a styrene-based resin.
By reviewing the literature it can be seen that VDOT reports and specifications have been the basis for revising CIPP specifications regarding water quality concerns.

3. Survey on CIPP Water Quality

3.1. Development of the Survey

A survey regarding CIPP contractors’ experience with potential water quality issues was developed and sent to PennDOT for approval. The PennDOT team reviewed the survey and sent their recommendations back. The revised survey is presented in the Appendix.

The survey was sent to 30 CIPP manufacturers and installers in Pennsylvania and nationwide.

3.2. Survey Responses

Eight recipients replied to the survey. These responses are presented in the Appendix. A summary of the responses is as follows:

- Four recipients acknowledged potential issues with styrene-based resins and suggested using products which utilize non-styrene based resins instead of styrene-based resins. Epoxy resin was mentioned as an example of a product that contains no VOC compounds and does not infiltrate any odor into buildings adjacent to a repaired sewer main. Silicate resin and sodium silicate resin were indicated as additional examples.

- One addressee stated that if CIPP is installed properly and good housekeeping is maintained on the site, the risk of environmental damage is extremely low. It is pointed out that contractors must cure the CIPP properly; capture all cure water, condensate, and resin; and prevent these materials from entering downstream waterways. Following VDOT recommendations is advised.

- One of the responses refers to guidelines for use and handling of styrenated resins in CIPP published by the National Association of Sewer Service Companies (NASSCO), which is an industry trade organization. This document states that “CIPP installation sites managed with good housekeeping will present little opportunity for human health risks and/or environmental risks”; and that studies show that CIPP resin systems do not appear to be a significant source of styrene or any of the other volatile organic compounds typically of concern in occupational or air quality studies.

- Two of the recipients stated that their specialty is in spray lining, which is a trenchless rehabilitation method different from CIPP.

Generally, the responses provided the same information presented in different reports. Although half of the responses mentioned the use of an alternative non-styrene based resin, one of the VDOT reports a case in which concentrations of the primary resin constituent (vinylic monomer) of a styrene-free CIPP exceeded toxicity thresholds for aquatic species water samples.

4. Summary, Conclusions, and Recommendations

4.1. Summary and Conclusions

The effects of the CIPP rehabilitation method on water quality were investigated. Literature from VDOT and other states was reviewed. VDOT was contacted for more information and a survey requesting information on the subject was sent to a number of CIPP manufacturers/installers.

The potential issues with water quality have been reported by VDOT and a number of investigations were conducted by their research division (VCTIR). Reports from other states generally refer to these investigations. One of the sewer service industry trade organizations (NASSCO) has guidelines which state that CIPP resin systems do not appear to be a significant source of styrene or any of the other VOCs typically of concern in occupational or air quality studies.

Current VDOT specifications include measures to ensure there are no adverse effects on water quality as a result of
CIPP installations. A new VCTIR study (November 2014) reports that chemicals other than styrene were released by CIPP into stormwater. It recommends that any further CIPP testing should not be limited to a few contaminants (e.g., styrene), but be expanded to include other contaminants of environmental and human health concern. In personal communication with VDOT it was said that the current specifications may not be stringent enough and that VDOT will soon meet to discuss how to proceed given the findings from the latest study.

### 4.2. Recommendations

It is recommended that PennDOT should consider adopting VDOT specifications while examining their applicability to PennDOT’s practices. The standardized test method presented in the latest VDOT report (reference number 5) needs further work to determine the ability of the test method “to predict field stormwater levels at multiple installation sites, for a broader range of materials, and evaluate additional water quality and toxicity indicators.” Therefore, it seems that more time is needed for the test to become a comprehensive test method. Additionally, it remains to be seen how VDOT will change its specifications in light of this new report. Consequently, monitoring action in this field is suggested.

Limiting the use of styrene-based materials could be an interim step taken by PennDOT. It should be noted that this does not relieve the potential concerns related to other contaminants.

It is recommended that a strategic plan be developed to resolve the issues associated with CIPP use. Some elements of this plan could include:

- Consider making monitoring measurements of water quality at Pennsylvania installations to establish a database which can support future actions.
- Assess the applicability of stream classifications as illustrated in the New York example.
- Monitor future efforts associated with CIPP by the VDOT.
- Consider participating in the pooled fund study on this subject, which VDOT is considering.

The investigators believe that pursuing these actions through a comprehensive plan presents the best opportunity for a satisfactory solution to CIPP-related environmental concerns.

### References

7. New York State Department of Transportation (NYSDOT), "Design Guidelines for Rehabilitation of Culvert and Storm Drain Pipe," EB 11-008, Highway Design Manual Revision No. 61, Chapter 8, 2011.
Appendix

Survey on CIPP and Water Quality

QES is working on a Pennsylvania Department of Transportation (PennDOT) project to update the Trenchless Pipe Rehabilitation (TPR) section (MS-0450-0030) of the publication 447 “Approved Products for Lower Volume Local Roads” (2011). In some research reports we have studied from other states, there have been some concerns about the water quality after cured-in place pipe (CIPP) installations were completed. Some of the water quality issues include: high concentration of styrene which is potentially carcinogenic and toxic to aquatic species and concentrations of a vinylic monomer exceeding the toxicity thresholds for aquatic species.

We appreciate it if you could provide us with your experiences, evaluation reports, and suggested solutions to the noted issues regarding this subject as well as site locations of installations.

Have you had any municipal owners who voiced any concerns regarding water quality after CIPP installation? If yes, what were the concerns and how were they addressed?

We also appreciate it if you could provide us with contact information for a number of site location owners as well.

Survey Responses

Some responses have received minor edits. Only relevant parts of the responses are presented.

1. Contact Information:
   John Heisler
   Quik Lining Systems, Inc.
   714-296-5262
   jheisler@quiklining.com
   www.quiklining.com

Response:
In answer to your question regarding styrene, some resins do not contain styrene. Epoxy resin does not contain styrene. This type of resin is typically used in lateral sewer lining. It contains no VOC compounds and does not infiltrate any odor into a building when used to line laterals from the building to the sewer main.

2. Contact Information:
   Mike Moore
   Business Development Manager
   PHONE: (810) 412-4740
   CELL: (810) 347-5754
   FAX: (810) 417-4743
   MMoore@S1Eon line.com

Response:
In regards to the studies on water quality after CIPP projects have been installed, I will say that I have been educating water and wastewater professionals on that very topic for quite some time now. In the early stages of development with CIPP, chemists and engineers were trying to find ways to shorten the cure times for these types of repair methodologies, and in the process, incorporated some harmful bi-products aka styrene. Not only are they known as carcinogens, but have also been known to shrink over time. This is the leading cause for infiltration to still be present post CIPP, due to the fact that the liner material has shrunk allowing for annular space between the product and host pipe.

In light of all this, we utilize a different form of catalyst with our system due to its environmentally safe properties and consistent, moderate flash points. The PipePatch system utilizes a sodium silicate resin which is an MDI polymer. We have also utilized a very unique mixing technique to insure that the product is being mixed consistently upon every install. The main features and benefits of the sodium silicate is it is styrene free, and gives off zero voes. Our installers typically consist of municipal / excavation contractors, small to large municipalities , and service plumbers.
Response:
If CIPP is installed properly and good housekeeping is maintained on the site, the risk of environmental damage is extremely low. Require the contractor to abide by standard practices of simply curing the CIPP properly, capturing all cure water, condensate and, most importantly, resin, preventing these materials from entering downstream waterways. VDOT had recommendations including rinsing the CIPP and then capturing the rinse water. Take a look at the VDOT recommendations.

Response:
I am writing you in response to your recent emailed request sent through our website (below) regarding styrene-free resins for CIPP applications. To supplement your research, one document that comes to mind is the 12th Report on Carcinogens published by the US Department of Human Health Services, which lists styrene as a “reasonably anticipated” carcinogen. The research backing up this listing has been challenged by a National Academy of Sciences panel but I believe the listing has been upheld. Additional information can be found at www.stryene.org.

There have also been cases where styrene odors are not tolerated because of their negative effects on people with respiratory ailments. This is common around hospitals, schools and nursing homes but has also been encountered in residential areas.

Off the top of my head, the agencies we have encountered recently that have developed or are exploring styrene-free initiatives include the City of Redlands, WA, Caltrans, Gwinnett County, GA and the Virginia DOT. It is also prevalent in California, the Pacific Northwest and British Columbia.

There were 2 projects we were directly involved with in which RS CityLiner, our styrene-free, epoxy CIPP for gravity sewer applications, was utilized. These are listed below.

- University of Portland (Portland, OR)
  - Project completed Sept 2006
  - 2500 LF of 10”-12” sanitary sewer
  - The university requested a styrene-free system due to the line’s location through campus and under a church (styrene odors were not desirable)
  - RS CityLiner CIPP utilized
  - Point of contact (contractor) - Dean Monk, Pro Pipe (602) 725-2794
  - Point of contact (owner) - Paul Luty, University of Portland (503) 943-7308

- Gwinnett County, GA
  - Project completed 20 11-2012
  - 18”-24” storm outfalls
  - Styrene-free resins required due to concerns with potential effects of residual styrene concentrations on aquatic life
  - RS CityLiner CIPP utilized
  - Point of contact (owner): Frank Matticolla, frank.matticola@gwinnettcountry.com (678) 376-7130
Response:
I think you are looking to speak with a manufacturer who will be able to provide the time and expertise you are looking for. We are a contractor.

Here is my experience;

We line sanitary sewer pipes only. We do not do potable water or recommend doing potable water with this product. There are some non styrenated resins that can be used on smaller diameter pipes, epoxy or silicate. I have not had any complaints on environmental impacts to the environment. I do however believe that the styrene cooks out after the resin has cured. No resin should get into waterways etc. The resin amounts used are precalculated and there typically is not much if any leftover. After the resin has cured it is essentially a hard plastic nothing leftover to get into a waterway.

Response:
I am familiar with the Virginia DOT concerns with CIPP and Styrene, however I believe it is the only state that seems to have a specific policy towards the use of styreneated liners for stormwater applications. The usual course of action in Virginia is to opt for the far more expensive resin which contains no styrene, or is considered styrene free.

I have attached a paper that I assisted with for NASSCO on styrene safe use and its effects on the environment.

Styreneated CIPP liners are used safely across the United States extensively. Minnesota, land of 10,000 lakes, and getting a foot of snow today has done hundreds if not thousands of stormwater applications with styreneated CIPP liners. Particularly the Minnesota DOT.

I am sorry, but I do not have a specific list as this has never presented a problem across the US other than Virginia to my knowledge.

Response:
You may be aware already, but Sprayroq is not a traditional CIPP product. Most of the CIPP products are of a polyester or Vinyester resin platform. Our technology is a spray applied, polyurethane material which is VOC-free and void of styrene and BPA. Two of our core products, Spraywall and Sprayshield Green 1 are NSF 61 approved for use in potable water. The third product in that grouping, Sprayshield Green 2, will be tested and most likely approved in 2015.
8. **Contact Information:**
Scot W. Snyder  
Business Development Manager  
Phone: (717)-285-3103  
Cell: (717)-725-0795  
Fax: (717)-285-2321  
ssnyder@abelrecon.com  
www.abelrecon.com

**Response:**
I am following up on behalf of your inquiry into TPR with Sprayroq, the manufacturer of structural CIP polyurethanes of which Abel Recon is the certified applicator in the Mid-Atlantic region. Our company has case history in PennDOT trenchless pipe rehabilitation in the spray applied polymers as well as UV cured CIPP.
OBJECTIVE

The purpose of this document is to provide municipalities with information and guidance towards having engineers evaluate the applicability of GRS-IBS for use on their local bridge projects.

INTRODUCTION

GRS technology consists of closely spaced layers of geosynthetic reinforcement and compacted granular fill material. GRS-IBS is a fast, cost-effective method of bridge support that blends the roadway into the superstructure. GRS-IBS includes a Reinforced Soil Foundation (RSF), a GRS abutment, and an Integrated Approach (IA).

I. PROCESS DESCRIPTION

Engineers must utilize the design and construction specifications provided as follows:

A. Federal Highway Administration:

B. Guidelines in this document provide additional information to FHWA-HRT-11-026 and FHWA-HRT-12-051. In instances where guidelines differ between the sources, this document takes precedence.

C. PennDOT current and applicable design standards, including, but not limited to PennDOT Publication 15M, Design Manual Part 4 on structures.


II. GRS-IBS DESIGN GUIDELINES

(in accordance with: FHWA-HRT-11-026 and FHWA-HRT-12-051)

A. SITE LIMITATIONS
   1. GRS-IBS is limited to bridges with simple span structures.
   2. Skew angle for GRS-IBS bridges shall be according to PennDOT Publication 15M based on the limitations of the proposed superstructure type.
   3. GRS-IBS is limited to span lengths up to 70 feet.
   4. GRS-IBS is limited to bridges with GRS abutment heights up to 30 feet.
   5. GRS-IBS is limited to sites with low scour potential.
   6. GRS-IBS is limited to maximum stream velocities for all storm events, less than and including the 100 year storm event. Maximum allowable “through structure” stream velocities are:
      a. < 7 fps: Conventional GRS construction utilizing standard hollow Concrete Masonry Units (CMUs) with friction connection.
      b. 7-10 fps: Complete concrete fill with rebar on standard hollow CMUs.
      c. 10-12 fps: Large CMUs (24” x 24” x 72”) with intermediate layers of geotextile wrap-faced at 8” intervals.
7. GRS-IBS is limited to sites with soil pH between 5 and 9.
8. Outlet pipes through the GRS-IBS are not permitted.

B. SITE EVALUATION
A site evaluation shall be performed in accordance with FHWA-HRT-11-026, Section 4.3.2.

C. SCOUR

1. Scour Depth:
   a. Footings are to be designed based on the total scour depth obtained from a scour design flood. The scour design flood is defined as a 100 year flood, the flood of record (if available), or the overtopping flood (if less than the 100 year flood), whichever results in the worst-case scour condition in accordance with PennDOT Publication 15M Section 7.2.2.
   b. The reinforced soil foundation shall be placed below this calculated depth in accordance with Hydraulic Engineering Circular 18 (HEC-18) -or- PennDOT Publication 15M Section 7.2.4.

2. Scour Protection:
   a. A properly designed scour countermeasure shall be placed to protect against local scour in accordance with FHWA-HRT-11-026, Section 4.3.3. Riprap protection shall be sized appropriately for the class of stone specified in accordance with PennDOT Publication 15M Section 7.2.5. It is recommended that CMU blocks which are solid be used at the bottom of the GRS wall for reinforcement, and CMU blocks of a different color can be used to indicate scour as per FHWA-HRT-11-026, Section 6.4.
   b. Potential for channel migration shall be evaluated. The effect of lateral channel movement on abutments may be mitigated by providing abutment setback or providing wingwalls that extend beyond the estimated channel migration distance. The RSF shall be protected from scour. In all cases, wingwall height and length shall be constructed to adequately protect the reinforced fill from channel scour and undermining from surface drainage.

D. BEAM SEAT:

1. The maximum Service I Bearing Pressure on the GRS beam seat shall be limited to 4,000 lb/ft².
2. A cast in place or precast beam seat with a concrete end diaphragm is required for concrete girders, steel/timber superstructure elements, or other similar superstructures without backwall support.
3. When the use of a superstructure type warrants a beam seat, the superstructure must be properly anchored to the beam seat to prevent lateral movement or uplift of the superstructure.
I. DESCRIPTION – This work consists of designing and constructing an Integrated Bridge System (IBS) using Geosynthetically Reinforced Soil (GRS) technology on a Reinforced Soil Foundation (RSF).

II. MATERIAL (in accordance with: FHWA-HRT-11-026 and FHWA-HRT-12-051). Materials must be obtained from a manufacturer listed in Bulletin 15 (unless otherwise noted) for projects with state or Federal funding and conforming to the following requirements:

A. FACING ELEMENTS

1. Concrete Masonry Unit (CMU): PennDOT Publication 408, Section 713, and conforming to the following requirements:
   a. Concrete strength of 3000 psi minimum. No additional payment will be made for higher strength concrete.
   b. Water absorption limit < 5%.
   c. Freeze thaw testing in accordance with ASTM C1262-10.
   d. "Standard CMUs", hollow or solid as required, with nominal dimensions of 8” x 8” x 16”.

2. Large CMU Unit: PennDOT Publication 408, Section 714, and conforming to the following requirements:
   a. Solid block with nominal dimensions of 24” x 24” x 72”. Consideration shall be given to the design/installation of necessary temperature and shrinkage reinforcement and any additional reinforcement or lifting devices necessary for handling the large CMU units.
   b. Concrete strength of 3000 psi minimum. No additional payment will be made for higher strength concrete.

3. Existing Abutments: GRS structures can be constructed behind existing bridge abutments, subject to PennDOT approval. In these cases, the existing bridge abutments effectively become part of the facing element of the GRS structure. The GRS shall be wrapped-faced using geotextile fabric against the existing abutment in accordance with FHWA-HRT-11-026, Section 7.3.3.

4. Other Facing Elements: Other facing materials may be used with District Bridge Engineer approval.

B. BACKFILL MATERIAL:

1. All backfill material shall consist of sound, crushed, durable particles, fragments of stone gravel free from organic matter or other deleterious material, with a minimum friction angle of 38 degrees.
   a. Reinforced Soil Foundation (RSF) Backfill: PennDOT 2A coarse aggregate. All backfill aggregates must be Type A. (PennDOT Publication 408, Section 703.2)
   b. GRS Abutment Backfill: AASHTO #8 is the preferred abutment backfill. Backfill may also consist of coarse aggregate conforming to AASHTO #8, #57, #67, or a combination thereof. All backfill aggregates must be Type A. (PennDOT Publication 408, Section 703.2)
   c. Integrated Approach Backfill: PennDOT 2A coarse aggregate (PennDOT Publication 408, Section 703.2) -or- Driving Surface Aggregate (DSA). (PennDOT Pub 447, MS-0450-0004)

C. GEOSYNTHETICS (Geotextiles)

1. Geosynthetic Reinforcement in Abutment, Reinforced Soil Foundation and Integrated Approach: Biaxial geotextiles with a minimum Ultimate Tensile Strength = 4,800 lb/ft or as required by design.
   a. Woven geotextile strength shall be as determined by ASTM D 4595. Geotextile reinforcement tensile strength at 2 percent strain shall be greater than the calculated required reinforcement strength in the direction perpendicular to the abutment wall face as outlined in FHWA-HRT-11-026, Section 4.3.7.
D. **Class A Cement Concrete:** Class A cement concrete for use in hollow block wall fill and cast in place coping. (PennDOT Publication 408, Section 704.1)

E. **Reinforcement Bars:** Deformed rebar of a size and spacing as required by design, epoxy coated or galvanized in accordance with PennDOT Publication 408, Section 1002.

F. **Aluminum Flashing:** Flashing, such as 4” x 1.5” aluminum fascia or equivalent, may be used to serve as a drip edge under the superstructure to shed potentially corrosive fluids off the dry cast block and to prevent animals from burrowing into the abutment. (Note: Flashing is not Bulletin 15 approved)

G. **Preformed Cellular Polystyrene:** Preformed Cellular Polystyrene Geotextiles shall conform to PennDOT Publication 408, Section 516.2 and ASTM C578. In addition, it should have expanded polystyrene filler or equivalent, having a compressive strength >10 psi. Total thickness of the foam board shall be 4 inches or greater depending on the abutment height.

H. **Asphaltic (bitumen) Coating:** An asphaltic coating shall be shop installed on the concrete beam ends where it will be embedded between the GRS abutment and the wing wall to seal the embedded concrete.

J. **Scour Countermeasures:** Rock Lining as defined in PennDOT Publication 408, Section 850. Rip-rap scour countermeasures shall be sized according to Hydraulic Engineering Circular 23 (HEC-23). Rip-rap size as required by design and as shown on the project drawings.

**III. CONSTRUCTION** (in accordance with: FHWA-HRT-11-026 (Chapter 7), and FHWA-HRT-12-051, Section 3)

A. **Equipment:** Use equipment that produces the completed GRS-IBS and maintain all equipment in a satisfactory operating condition as specified in PennDOT Publication 408, Section 108.05(c).

   1. **Compaction Equipment:** Rollers and other compaction equipment as described in PennDOT Publication 408, Section 108.05(c) 3.d, 3.g, 3.h, and 4.

B. **Excavation:** Construct embankments and/or cut existing grade to the bottom of footing elevations. Excavate and backfill foundation areas as specified in PennDOT Publication 408 Section 204.3 and compact using a mechanical tamper or vibratory compactor. If unsuitable foundation material is encountered, remove all unsuitable material at least 12” or as specified or directed below the bottom of the RSF elevation and backfill with compacted No. 2A Coarse Aggregate as specified or directed. No additional payment shall be made if rock is encountered during excavation.

C. **Compaction of Backfill (RSF, Abutment, and Integrated Approach):** Hand-operated compaction equipment as specified above is required within 3 ft of the front of the abutment wall face.

   1. **Compaction of Open-Graded Backfill in Abutment:** Compact to non-movement or no appreciable displacement with compaction equipment specified above and assess with visual inspection (minimum of 4 vibratory passes per lift). Abutment backfill is to be placed at a maximum compacted depth of 4 inches per lift.

   2. **Compaction of Well-Graded Backfill in Reinforced Soil Foundation and Integrated Approach:** Compact well-graded backfill to not less than 100% of the determined dry-weight density. Dry-weight density for material in place in the field will be determined, in accordance with Pennsylvania Testing Method (PTM) No. 106, Method B. In-place density or compaction will be determined, in accordance with PTM No. 402 where directed. At the time of compaction, maintain the material's moisture content not more than 2 percentage points above optimum moisture for that material. Backfill is to be placed and compacted in lifts shallow enough to achieve 100% compaction, not to exceed 8 inches (loose) in a single lift.
D. GRS Abutment Facing

1. All CMU block walls shall be constructed with a vertical face.

2. Reinforcement of Facing-wall/Wing-wall Corners for Flows <7 fps Maximum Stream Velocity:
   
   a. The top three courses of Standard CMU block shall be filled with Class A cement concrete (PennDOT Publication 408, Section 704) with one #4 epoxy coated reinforcement bar of sufficient length to engage all three courses of block, embedded with a minimum of 2" cover, and provided with a cast in place cap in accordance with FHWA-HRT-11-026, Section 7.7.7.

   b. All courses of hollow CMU blocks on the facing-wall/wing-wall corners shall be filled as described in Section 2.a above. This shall include a minimum of 3 block columns comprised of the corner unit, and one unit on each side of the corner unit.

3. Reinforcement of Facing-wall/Wing-wall for Flows of 7-10 fps Maximum Stream Velocity:

   a. All courses of hollow Standard CMU blocks on the facing-wall and wing-walls shall be filled with Class A cement concrete (PennDOT Publication 408, Section 704), #4 epoxy coated reinforcement bars of sufficient length to engage all courses of block, and embedded with a minimum of 2" cover and provided with a cast in place cap in accordance with FHWA-HRT-11-026, Section 7.7.7.

4. Construction of Facing-wall/Wing-wall for Flows of 10-12 fps Maximum Stream Velocity:

   a. Large CMUs (24" x 24" x 72") shall be used. In addition to horizontal geotextile layers between blocks, two additional intermediate layers of geotextile shall be used behind each block, wrap-faced against the GRS wall so that geotextile spacing is at 8" intervals.

E. Site Drainage

All GRS structures shall include consideration for surface drainage both during and after construction in accordance with FHWA-HRT-11-026, Section 7.1.1 and Section 8.2.

IV. MEASUREMENT AND PAYMENT – Lump Sum. Includes all excavation required for GRS-IBS placement, the Reinforced Soil Foundation (RSF), the GRS abutments, the integrated approach, geotextile, backfill material, CMUs, and scour protection. Does not include the beam seat (when required), superstructure, removal of the existing structure as defined in the contract drawings, temporary support and excavation systems if required, dewatering and other erosion and sedimentation control measures, stream diversion, maintenance and protection of traffic, or approach roadway items.
OBJECTIVE

The purpose of this document is to provide municipalities with information and guidance towards having engineers develop contract documents regarding fabrication specifications and installation criteria for a timber bridge superstructure.

INTRODUCTION

Timber bridge superstructures can come in a variety of configurations. These guidelines were developed with pressure treated dowel laminated timber slab span structures in mind but can be modified for use on other timber structure types.

I. PROCESS DESCRIPTION

Engineers must utilize the design and construction specifications provided as follows:

A. American Association of State Highway and Transportation Officials (AASHTO)
   1. Manual for Assessing Safety Hardware (MASH)
   2. LRFD Bridge Design Specifications.

B. PennDOT current and applicable design standards, including, but not limited to
   1. Design Manual Part 4: Structures (Publication 15M)
   3. Bridge Safety Inspection Manual (Publication 238M)
   4. Specifications (Publication 408)

C. PennDOT standard drawings (PennDOT Publications 6M, 218M, and 219M)

D. Guidelines in this document provide additional information to the above references. In instances where guidelines differ between the sources, this document shall take precedence.

E. It is the design engineer’s responsibility to review and modify, if necessary, the design guidelines and/or specifications herein based on project requirements and site conditions.

II. DESIGN GUIDELINES

A. GENERAL

1. The bridge design shall include loading, substructure configuration, superstructure configuration, railings, barriers, connections, approaches and other structural features of the bridge. Design procedures, analysis, and safety factors shall be in accordance with AASHTO LRFD Bridge Design Specifications as supplemented by Pennsylvania Department of Transportation Design Manual Part 4: Structures (DM-4).

2. The design life of the timber bridge superstructure, including hardware and appurtenances, shall be 50 years minimum.

3. Design of the bridge substructure and superstructure shall include an evaluation of AASHTO and DM-4 LRFD load combinations.

4. Bridge deflection under 125% of the larger of 1) one design vehicle as specified in AASHTO 3.6.1.2.2 or 2) 25% for one design truck with the variable axle spacing combined with the effect of the design lane, shall not exceed span length/425.

5. Glued laminated members shall be cambered in accordance with Publication 6M.
B. SUPERSTRUCTURE

The timber bridge superstructure structural design shall consist of members and components above the bearing of the bridge on the abutments and piers.

1. Wearing Surface
   a. Bridge deck wearing surface may consist of treated lumber or asphalt as determined by the Owner.
   b. The wearing surface shall be designed and installed such that it protects the structural deck components from both vehicle damage and abrasion and effects of the environment.
   c. Superstructures utilizing a bituminous surface shall be designed with a dead load of 140 pounds per cubic foot.
   d. Superstructure shall be designed for a future wearing surface of 30 pounds per square foot over the roadway surface (roadway and shoulders).
   e. Bituminous cross-slope shall be no less than 2% to provide adequate runoff.

2. Deck
   a. The deck width shall consist of full-width panels.
   b. The deck shall be dowel or glue-laminated.

3. Guiderail
   a. Guiderail consists of rail, posts, curb, scupper blocks, rail blocks, and connection hardware. Guiderail shall be of a design that meets or exceeds the crash test level required for the roadway as defined in Design Manual Part 2 based on the volume of traffic and the roadway classification.
   b. Documentation that the proposed guiderail meets the appropriate AASHTO test level shall be submitted and approved prior to fabrication of components affected by this requirement.
   c. Guiderail shall be structurally integrated with the deck system and shall not be structurally connected to the substructure.

C. SHOP DRAWINGS

At a minimum, the following criteria for shop drawing submission, review and approval shall be incorporated into the contract bid documents through either the contract specifications or on the design drawings. Owners should retain the design engineer to review the structural adequacy of the shop drawing calculations and details.

1. Calculations
   a. Detailed and complete structural design calculations that form the basis for bridge dimensional and material specifications, including assumptions, loading and load combinations, shall be submitted to the Owner no less than 30 calendar days prior to the intended initiation of fabrication. Structural design calculations shall be sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania.
   b. Written certification that the timber bridge was designed in accordance with the contract drawings.
   c. Load rating. Prior to bridge fabrication, perform and submit structural calculations, sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania. Load ratings shall be done in conformance with Publication 238.
   d. Fabrication shall not begin without structural adequacy approval of structural calculation submittals required in this section.
   e. No extension of time or additional compensation will be granted to the contractor due to delays in structural calculation submittal approvals.
2. Drawings

Shop and Construction Plan Drawing Requirements – see Pennsylvania Department of Transportation Publication 408: Specifications Section 105.02(d):

a. Shop and construction drawings and specifications shall be sealed by a licensed Professional Engineer licensed in the Commonwealth of Pennsylvania.
b. Critical bridge dimensions shall be clearly identified.
c. Shop drawings and material certifications shall be submitted with shop drawing calculations to the Owner for approval.
d. Methods of manufacture, fabrication, and assembly, installation, and erection procedures shall be included in the shop drawings.
e. Approval of the submission is required prior to proceeding with fabrication.

I. DESCRIPTION

This work consists of furnishing and installing a pressure treated dowel Panel-lam timber slab span structure in accordance with the bid documents.

II. MATERIALS

As indicated and as specified for each respective item included in the bridge structure.

Lumber and Timber shall meet the requirements of AASHTO M168, Graded as per NFPA National Design Specifications for Wood Construction.

III. CONSTRUCTION

As indicated and as specified in the applicable sections of Publication 408, Supplements thereto, and/or the Special Provisions for each respective item included in the construction of the structure.

Do not commence construction until the shop drawings are approved. Construction may commence on components of the substructure provided that partial structure plans are approved.

Bridge supplier/ fabricator is not responsible for the structural design of the bridge foundations or substructure. Supplier shall review the substructure drawings only to verify the dimensional requirements for the bridge installation. Bridge supplier is not responsible for the design of the roadway profile and alignment.

Superstructure - Structure length shall be as shown on the plans and be determined as out to out of bridge superstructure. Width shall be as appears on the project plans and determined as face to face of railing.

The structural design of the bridge structure shall be performed by or under the direct supervision of a Professional Engineer licensed in the Commonwealth of Pennsylvania and done in accordance with recognized engineering practices and principle.

Proposed suppliers shall have at least five (5) years’ experience designing and fabricating these type structures and a minimum of five (5) successful bridge projects, of similar construction, each of which has been in service at least three (3) years. List the location, bridge size, owner, and a contact for reference for each project.

Anchor bolts will be furnished in advance for incorporation into substructure units. Delivery of the structure shall be coordinated between supplier and contractor.

NOTE: The effects of fabrication tolerances shall be accounted for in the design of the structure.

The bridge supplier/fabricator shall provide technical assistance to the Contractor throughout the construction process. The bridge supplier shall have a Technical Advisor on site during setting of the bridge components. The advisor shall have successfully installed 10 bridges prior. Resume of on-site technical assistant should be provided at the time of submittal for approved fabricator consideration along with the other required documents. The Technical Advisor shall provide assistance upon request but neither the Technical Advisor nor the Bridge Manufacturer will be held responsible for any accident, personal injury or property damage that occurs during erection. Contractor to make arrangements in advance with supplier.

The Contractor shall furnish complete sets of stamped shop drawings and calculations for superstructure. An assembly manual shall be part of the submittal. Drawings and calculations shall be signed and sealed by a Professional Engineer licensed in the Commonwealth of Pennsylvania.

Structural calculations for the bridge superstructure shall be submitted by the bridge manufacturer and reviewed by the approving engineer. The calculations shall include design information necessary to determine the structural adequacy of the bridge.

IV. MEASUREMENT AND PAYMENT

Lump Sum. Includes timber elements and connection hardware necessary to construct the bridge (and timber guiderail). Does not include maintenance and protection of traffic, bituminous surface material and waterproofing membrane (if necessary), or approach roadway items including but not limited to pavement, drainage, and approach guiderail.
Appendix A:
Existing standards referenced and where necessary modified herein as required.

Pennsylvania Publication 15M

This specification references the following American Society for Testing and Materials (ASTM) standards.


ASTM C138-Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

ASTM C403-Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance.


ASTM C942-Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.


ASTM D638-Test method for Tensile Properties of Plastics.


ASTM F 1216-Test Method of Flexural Properties of Plastics.


ASTM F1606-Standard Practice for Rehabilitation of Existing Sewers and Conduits with Deformed Polyethylene (PE) Liner.


ASTM F1698-Standard Practice for installation of Poly (Vinyl Chloride) (PVC) Profile Strip Liner and Cementitious Grout for Rehabilitation of Existing Man-Entry Sewers and Conduits.

ASTM F1735-Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Strip for PVC Liners for Rehabilitation of Existing Man-Entry Sewers and Conduits.


ASTM F1867-Standard Practice for Installation of Folded/Formed Poly (Vinyl Chloride) (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation.

ASTM F1871-Standard Specification for Folded/Formed Poly (Vinyl Chloride) Pipe Type A for Existing Sewer and Conduit Rehabilitation.


400 - 40
I. DESCRIPTION — Salt Brine is a liquid mixture of potable water and approved Sodium Chloride. It is generally placed on roadways prior to a snow storm or other winter event to prevent the snow from bonding to the roadway. Please note that most of the information below is from derived from Penn DOT Publication 23, Bureau of Maintenance and Operations, Maintenance Manual, Chapter 4.

II. MATERIAL— Approved Sodium Chloride is mixed with potable water in a specially designed machine which circulates the water through the salt, in one tank, to a holding tank which holds the finished product. The solution is ready for use when the level of salt in the liquid is as close as possible to 23.3%. This can be checked by a Hydrometer or Salometer.

The machine can be purchased from a vendor or can be constructed locally but must have two tanks. One for mixing and one for holding the finished product. When product is stored it must be remixed every thirty days, or before its use, or sale to insure the solution is in proper condition. Additional storage tanks to store the finished brine are acceptable, however 30 day mixing is required.

The finished Salt Brine can then be used to pre-treat road surfaces before a predicted winter storm event or used as a pre-wetting agent to treat Sodium Chloride or a Mixture of Abrasives and Sodium Chloride from the stockpile that will be used for salting and cindering operations during the storm.

An attachment is included with this specification which help explains this information.

III. PLACEMENT— As an anti-icing treatment use the Decision Tree (attached). The Brine can be placed on roadways prior to the arrival of a winter event.

The distribution unit used for anti-icing can be purchased or constructed locally but must be able to place the brine on the roadway at a rate recommended in the following attached document (PUB 23, Chapter 4).

In the attachment, see suggested application rates for roadways and suggested amounts for pretreat Salt and Mixtures of Salt and Abrasives.

IV. SALE OF SALT BRINE - If one municipality desires to purchase Brine from another municipality using Liquid Fuels monies, the following steps must be followed:

- An agreement between the municipalities must be on file in each liquid fuels folder. A letter signed by both Municipalities, seller and buyer, agreeing to price or other method of payment shall be included in that letter.
- The municipality which makes the Brine must keep a record of the date, time, and percentage of salt in the mix when made. The Brine must be tested again on the day when the purchasing municipality receives the product.
- Brine should meet a reading of close as possible to 23.3% before transferred to the purchasing municipality.
- A statement on letterhead must accompany the invoice of the selling municipality when sold to verify the salt percentage and gallons purchased. The purchasing and selling municipality must retain this in their folder.

V. MEASUREMENT AND PAYMENT— Gallon.

VI. ATTACHMENTS— included on the following pages.

Additional information on use of this product. It is highly recommended that the municipality follow the PUB 23, Chapter 4 excerpts attached when making and using Salt Brine because of its tried and true results
The following information is obtained from Penn DOT Publication 23, Bureau of Maintenance Operations, and Maintenance Manual. It is highly recommended that municipalities follow the methods for Anti-Icing and other approved methods as shown.

4.5.4 MATERIAL APPLICATIONS, AND OTHER WINTER ACTIVITIES

I. PRE-WETTING SALT— There are several advantages to pre-wetting salt:

- Reduced loss of salt from bounce and scatter
- Quicker melting
- Better salt penetration into ice and snow pack
- Melts at a lower temperature if wetted with other deicing chemicals
- Salt can be spread more uniformly with less waste on shoulders and in ditches because wetted salt sticks to the pavement
- The amount of dry materials used can be cut by 20-30% because of the dual action of added brine and more materials remain on roadway
- Works faster because more brine is present
- Driving/spreading speeds can be increased because salt stays on the roadway

Any deicing chemical can be used for pre wetting. Liquid salt, calcium chloride, magnesium chloride, or blends are commonly used. Chemicals with lower eutectic temperature (lowest temperature at which it can still cause melting) help extend salt effectiveness on lower temperature pavements. The melting effectiveness of both dry and pre-wet salt decreases as road temperatures drop; below 10° F, there is almost no melting benefit from straight salt.

Salt is usually pre-wetted with 6-12 gallons of liquid per ton of salt. Pre-wetting can be done in the stockpile; as spreader trucks are loaded; or by spraying the salt as it is spread on the road. Pre-wetting at the shop requires less equipment but reduces flexibility of use. Pre-wetting on board the truck allows better coverage and treatment as needed. On-board pre-wetting at the auger shows better coverage than spray at the spinner, however, both methods are acceptable.

Savings are possible if operators reduce application rates when spreading pre-wetted salt to take advantage of its faster action and lower salt loss. Field research has documented equal or improved performance of 20% less pre-wetted salt compared to dry salt.

II. PRE-WETTING ANTI-SKID— Pre-wetting anti-skid may be used to reduce wasted material. Pre-wetting at rates of 10-30 gallons of liquid chemical per ton of anti-skid abrasives has proven effective.

III. ANTI-ICING— Anti-icing is a proactive snow and ice control strategy. A small amount of liquid chemical is applied to pavements and bridge decks before a storm to prevent snow and ice from bonding with the surface. By contrast, deicing is the application of chemical during or after a storm to break the ice/pavement bond so plows can clear the road.

Anti-icing is commonly used on pavements where the practice is to provide a high level of service. It has proven very effective at preventing bridge deck and pavement frost. Specialized equipment is needed to apply small amounts of liquid chemicals. Detailed weather predictions are also helpful.

Benefits of anti-icing: An anti-icing strategy can produce significant benefits:

- Better pavement conditions (improved friction) can be achieved, reducing the number of crashes. (One study in Idaho reported 83% fewer crashes)
- Less chemical is required to prevent ice bonding than to remove ice after it has bonded to the pavement. Anti-icing applications are reported to last for several days, particularly in preventing frost on bridge decks
- Clean-up after a storm may be easier with less ice bonded to pavement.
- Application can be made during regular working hours, reducing some overtime costs.
• Anti-icing can reduce airborne dust and salt particulates.
• Salt needs moisture to be effective. Applying brine jump starts the melting process.
• Brine sticks to the road's surface. It will not be as easily blown of the road by wind or traffic, so material is more efficiently used.
• If the storm is delayed, salt residue remains on the road ready to begin work when precipitation begins.
• Crews can begin treatment in advance of a storm. Because Anti-Icing prevents the bonding of snow and ice to pavement, snow fighters have less work to maintain safe roadways as the storm progresses.
• Increased efficiency results in use or less deicer and manpower, therefore lowering the cost of maintaining safe road conditions. The use of less deicing materials also minimizes environmental concerns.

IV. GUIDELINES FOR ANTI-ICING

• Refer to the anti-icing tree for developing an anti-icing strategy prior to an event. All levels of networks of highways may be considered for anti-icing based on local need or at the county manager’s discretion. The following guidelines have been established for proper execution of anti-icing:

V. WHEN TO ANTI-ICE

• Anti-icing should be the first in a series of strategies considered to reach winter storm.
• Anti-icing should be conducted prior to forecasted frost, freezing fog, or black ice events on bridge decks and pavement trouble spots as a minimum, assuming conditions in this guideline or anti-icing are met. Other areas (hills, curves, shaded areas, ramps, or intersections) may be treated as determined by the county, on an as-needed basis.

Treatment for frost or black ice incidents can be made on a regular schedule; twice per week during the typical frost season (beginning and end of the winter months), or in accordance with weather forecast information. Applications in anticipation of a possible frost incident or snow event on a Saturday or Sunday may be made on the preceding Friday.

• Anti-icing should be done during normal, low traffic volume, non-overtime work hours. In the case of a county with normal overnight working hours, anti-icing can be done at night or other off peak traffic times. In counties where split shifts are not used, anti-icing should be done so as to minimize disruption to the traveling public. Applications should normally be made 12-18 hours prior to a predicted frost or snow event depending on the material used. Some anti-icing agents will last longer than others.

• When traffic volumes are high, use of a following vehicle for traffic control may be necessary. Due to high traffic volumes, additional application may be required if the anti-icing agent residue is worn off the bridge deck or pavement surface.

• It is desirable to have completed anti-icing operations on first priority and high-ADT routes two hours prior to the onset of an event or at least prior to snow and ice bonding on the road surface.

• Anti-icing may also be conducted prior to predicted light sleet and light (less than 0.5"/hr) or moderate (0.5"-1.0"/hr) snow events. If precipitation persists, additional anti-icing applications may be necessary to prevent refreeze due to dilution of the chemical or switching to deicing applications may be necessary.

• Anti-icing should be conducted when the pavement temperature is at or above 15° F or the pavement temperatures are forecast to rise or stay above 5° F.

• Liquid agents are the preferred material for anti-icing treatments. Although applying pre-wetted salt prior to an event can technically be considered anti-icing, liquid agents work more effectively than solids and there is also less waste with liquid applications.

• Counties may coordinate their anti-icing strategies with each other to maintain consistency when crossing county or district boundaries. BOMO personnel may also be consulted for support in these cases.
VI. WHEN NOT TO ANTI-ICE

Liquid anti-icing should not be conducted:

- Prior to forecast of rain turning to frozen precipitation.
- When winds are more than 15 MPH.
- When the anti-icing agents have the potential of causing snow to stick to the roadway under blowing and/or drifting snow conditions.
- When the pavement temperature is below 15°F or forecast to fall below -5°F.

VII. PRECAUTIONS

Verification - Liquid Anti-icing application equipment application accuracy should be verified at the beginning every winter season. Application equipment that has been transferred to another truck, modified, or repaired should also be verified. Equipment should be monitored during use and adjusted and rechecked when performance appears questionable.

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<th>Anti-Icing Application Guidelines</th>
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<td><strong>Liquid Chemicals</strong></td>
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<td><strong>Relative Humidity</strong></td>
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<td><strong>Surface Temperature 25° and Above</strong></td>
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<td><strong>Surface Temperature 15°-24°</strong></td>
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<td><strong>Surface Temperature 14° and Below</strong></td>
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Persistence - If not diluted by rain or snow, residues of liquid anti-icing agents can remain on the surface for up to four days after application. When rain, snow, or moisture in the air dilutes the residual anti-icing agent on the surface, refreezing can occur. Reapplication may be needed.

Slipperiness - Reduce application rates after dry spells, especially when pavement temperatures are warm (45°-50° F), when humidity is 45%-55%. Bridge decks and pavement surfaces where residues of oil products and/or rubber have built up may become slick when sprayed with an anti-icing liquid.

Sodium Chloride - The use of sodium chloride (common salt) combined with snow plowing is the most effective, most economical and safest snow and ice control method currently available. Salt is most effective for melting purposes at temperatures above 20 degrees F., with reduced melting ability as the temperature drops. In general, the purpose of salt is to (1) reduce adherence of snow to the pavement, (2) keep the snow in a "mealy" condition and thereby permit nearly full removal by plowing, and (3) prevent the formation of ice or snow ice (hard pack). Salt is not intended to take the place of snowplows. It is economically and environmentally unacceptable to attempt to melt snow accumulations that are plowable.

Calcium Chloride - Calcium chloride is a chemical which melts ice at lower temperatures than sodium chloride. Flake calcium chloride is used as an additive to abrasives (anti-skid) to prevent freezing in stockpiles, to thaw culverts and catch basins, to help hold the abrasive in place on the pavement and on rare occasions to trigger sodium chloride action. Liquid calcium chloride at 32% strength can be used to pre-wet solid sodium chloride to trigger the chemical reaction at low temperatures. The addition of liquid calcium chloride so is beneficial in retaining de-icing material on the road way by increasing the adhesion of the material to the roadway.

Abrasives - Abrasives (fine mineral aggregates) are used primarily for immediate traction on hills, curves, intersections, railroad crossings and other areas and to minimize the use of salt. This does not include sand or fly ash, which is a common misconception. Sodium chloride, calcium chloride or an appropriate mixture of the two are usually added to abrasives in amounts dependent upon existing weather conditions. Stockpiles of abrasives are usually treated with chloride at the start of the season to prevent subsequent freezing.
VIII. APPLICATION OF DE-ICING MATERIALS

The use of chemicals, abrasives or chemical-abrasive mixtures is dependent not only on present roadway and weather conditions, but also on anticipated changes in these conditions and fiscal or logistic constraints experienced by PennDOT. The effects of peak traffic periods, approaching nightfall or daybreak, precipitation type, and predicted end of storm, are considered and evaluated prior to selecting the proper materials and rate of application.

Adverse roadway conditions existing during periods of low temperatures, which are predicted to rise, would generally be treated in accordance with the recommendations for the higher temperature. If the time of day, trend and weather forecast is such that a drop in temperature may reasonably be expected, treatment would generally be in accordance with the recommendation for the lower temperature.

Chemicals or abrasives should not be used at low temperatures if the pavement is dry and snow is blowing off the pavement as such use would be wasteful and may be counterproductive.

Note: Chemical deicing materials are not recommended for Dirt & Gravel Roads.

IX. RATES OF APPLICATION

Generally, Sodium Chloride is the chemical of choice or most storm situations. Sodium chloride is used to prevent snow pack and ice build-up on the pavement and to aid removal of any build-up that occurs. Instructional guidelines are recommended to adequately maintain highways under most conditions and can be found in Appendix H.

Chemicals or mixes are normally applied to the middle V3 of pavement width and on the high side of banked cures. Spread width may be increased or decreased depending on the action of traffic. Materials are applied early in the storm so that brine develops on the pavement and prevents build-up of packed snow. It takes much less deicing chemical to remove compacted snow when the treatment is placed between the pavement/snow layer than if it is placed on top of the snow. If snow continues and accumulates on the pavement, plowing should continue and additional chemical or mix-treatments should be made if compaction develops.

There are many additional circumstances which will necessitate modification to these treatments. Some of these circumstances are:

1. Rising or falling temperatures.
2. When pavement is cold and dry and snow is falling, chemicals are not applied. Plowing and treatment of icy spots, if they develop, is recommended.
3. An abrasive chemical mix may be needed at extremely low temperatures or on very lightly traveled highways. Under these conditions the effectiveness of salt is reduced and abrasives may be needed for traction.

APPENDIX C - ANTI-ICING DECISION TREE

ANTI-ICING DECISION TREE DIRECTIONS

- Use this decision tree once per day and/or whenever the current weather forecast is significantly updated.
- If the decision tree recommends against anti-icing but conditions have changed, reevaluate the decision based on the new situation.
- If there is a winter storm forecast for sleet, snow, freezing rain or frost that will adversely affect driving conditions, it is desirable to have some form of salt residue on the road.
- If there is no or very little salt residue on the road surface, anti-icing is recommended, except under the following conditions.
- If the event is forecasted to start as rain.
- If the road surface temperature is below 15°F.
- Some judgment is required to decide if the storm event will be sufficient to cause driving problems. However, you should always err on the side of anti-icing, as it is a very cost effective treatment.
GENERAL PRINCIPLES OF ANTI-ICING

- Anti-icing can commence at least 48 hours in advance of the forecasted start time of a winter storm where practical. Bituminous pavements should be anti-iced first, then Portland Cement Concrete pavements. Higher priority routes should be anti-iced last as this reduces the potential for "dust-off."

- Once the decision to anti-ice has been made, the (45 gai/SLM minimum) rate may need to be increased to double the normal value to compensate for circumstances that would otherwise deplete the salt residue below value likely to be effective. These circumstances include applying salt brine more than 24 hours before the anticipated event, roads that have surfaces on which normal anti-icing rates have been observed to be ineffective and sleet and/or freezing rain are anticipated.

- One key to a successful anti-icing program is to have quality salt brine as close to 23.3% solution as possible. Another key is to calibrate the anti-icing equipment at the beginning of and several times during the winter season.
Section 500
Traffic Accommodation and Control
I. DESCRIPTION — This work is the furnishing and installation of reflective sign post panels of the type indicated on either existing posts or posts installed for other purposes.

II. MATERIAL — As shown on the standard drawing or manufacture’s specification and as follows:

A. Panels. Provide materials from an approved manufacturer. Certify materials as specified in Publication 408, Section 106.03(b)3. Furnish cutout retroreflective sheeting material of the color indicated and at a minimum 2 inch in width and a maximum of 2 inch wider than post width being used.

B. Aluminum bolts nuts, lock-washers; brackets and bars (supports); lag screws; anti-theft sign hardware; banding-Publication 408, Section 1103.11.

III. CONSTRUCTION —

A. Attach panels permanently to supports as shown on the standard drawing or manufacturer’s specification. Mount the panel in a level position, correctly aligned, and firmly attached with anti-theft hardware.

B. Install panel for the full length of the support from the sign to within 2 feet above the edge of the roadway. Its color shall match the background color of the sign, except that the color of the strip for the YIELD and DO NOT ENTER signs shall be red. Use red on the reverse side of any post where a road user traveling in the wrong direction on that particular ramp or roadway would view it. Panels shall consist of retroreflector units that are capable of clearly retroreflecting light under normal atmospheric conditions from a distance of 1,000 feet when illuminated by the high beams of standard automobile lights.

IV. MEASUREMENT AND PAYMENT — Square Yard of panel. The unit price includes removal of existing panel(s), as necessary.
I. DESCRIPTION — This work is the preparation of the asphalt pavement surface area, supplying and placing an in-laid pre-cut thermoplastic pavement marking Decorative Crosswalk System, material, color and pattern as shown on the plans. The thermoplastic material is provided in sheets that are die-cut to match a prescribed pattern, thereby minimizing joints in the final product. Prepare the asphalt pavement to receive the thermoplastic sheet. Provide a template matching the pattern of the thermoplastic used to imprint depressions into the pavement.

II. MATERIAL —

A. Certification. MS-447A

   1. Where directed, replace material that has not remained within reasonably close conformity to location or has not remained effective in performing useful service for a period of 180 days from the date of acceptance. The service is as follows:
      • 90% of material remains in each crosswalk.

B. Inlaid Thermoplastic Material.

   2. **ASTM D523**: Sheen ≥ 1 at 85°
   3. **ASTM D412**: Tensile Strength ≥ 400 psi, but can be waived if ASTM D4541 values exceed 400 psi
   4. **ASTM D4060**: Abrasion Resistance: Maximum loss 100 mg/1000 cycles, based on net loss between 500 to 1000 cycles.
   5. **ASTM D4541**: Adhesion to Asphalt ≥ 180 psi
   6. Meet Manufacturers Specifications

III. CONSTRUCTION —

A. Weather restrictions.

   1. Do not install during periods of precipitation
   2. Do not place system when air or surface temperature is 40° F or lower

B. Pattern and Color Limitations.

   1. Refer to Publication 111M, TC-8600 Series Standard Drawing for approved colors and patterns.

C. Surface Preparation.

   1. Place only within the planned designated areas.
   2. Apply system to only asphalt surfaces that show no excessive oxidation. The existing pavement shall be stable, well compacted and in excellent condition. Repair of ruts, raveling, cracks, visible seams, and shallow points, is required before acceptance of the pavement surface by the installer.
   3. Clean the surface of all loose particles, dirt, grease, and any other substance that may reduce the system’s ability to adhere to the existing surfaces.
D. Placement

1. Preheat road surface to between 235°F to 326°F utilizing an indirect heating mechanism that allows surface temperature monitoring at all times, gradually heat-saturate the mat without causing damage. Use of open flame and constant heat exposure is not allowed.

2. Heat soak (soften) the road surface to a minimum depth of 1/2 inch

3. Do not place materials if the mat temperature has exceeded 326°F

4. Utilize templates and vibratory tampers to imprint the pattern to a depth of no less than 1/8 inch

5. Place the Pre-Formed/Pre-Cut Thermoplastic Material in accordance to plan and with the manufactures recommendations

6. Utilize vibratory plate compactors to press the templates into the heated asphalt surface

7. Border the decorative crosswalk by installing two white parallel lines (minimum 6 inches thick) with a PennDOT approved pavement marking material that extends from face of curb to face of curb or edge of shoulder

IV. MEASUREMENT AND PAYMENT — Square Yard
I. DESCRIPTION — This work is the preparation of the area, supplying and placing a modified polyurethane resin-aggregate mixture as surface dressing, finishing and texturing the system in order to construct decorative crosswalks with the specified color, material, and texture pattern shown on the plans.

II. MATERIAL—

A. Certification. MS-447A
   1. Where directed, replace material that has not remained within reasonably close conformity to location or has not remained effective in performing useful service for a period of 180 days from the date of acceptance. The service is as follows:
      • 90% of material remains in each crosswalk.

B. Decorative modified polyurethane resin crosswalk.
   2. ASTM D523-08: Sheen ≥ 1 at 85°
   3. ASTM D412-06a: Tensile Strength ≥ 400 psi, but can be waived if ASTM D4541 values exceed 400 psi.
   4. ASTM D4060-10: Abrasion Resistance Maximum loss 100 mg/1000 cycles, based on net loss between 500 to 1000 cycles.
   5. ASTM D4541-9a: Adhesion to Asphalt ≥ 180 psi
   6. Meet Manufactures Specifications
      Furnish a material with a minimum initial skid resistance of 50 British Pendulum Number (BPN) for all crosswalks, stop lines, or where indicated.

C. Aggregates. ASTM C295/C295M-12, Meet manufacturer’s specifications

D. Resin-based synthetic asphalt compound. ASTM D-4690-99, Meet manufacturer’s specifications

E. Reinforcement fibers. Meet manufacturer’s specifications

III. CONSTRUCTION —

A. Weather restrictions.
   1. Do not place system when precipitation is expected within 24 hours.
   2. Do not place system when air or surface temperature is 10°C (50°F) or lower.

B. Pattern and Color Limitations.
   1. Refer to Publication 111M, TC-8600 Series Standard Drawing for approved colors and patterns.
C. Surface Preparation.

1. Place only within the plan designated areas.
2. Apply system to only asphalt or concrete surfaces.
3. Apply system to only asphalt surfaces that show no excessive oxidation. The existing pavement shall be stable, well compacted and in excellent condition. Repair of ruts, raveling, cracks, visible seams, and shallow points, is required before acceptance of the pavement surface by the installer.
4. Mill all applicable leading edges to a consistent vertical depth 3/4 inch below the existing grade.
5. Clean the surface of all loose particles, dirt, grease, and any other substance that may reduce the system’s ability to adhere to the existing surfaces.
6. Seal concrete surfaces with a material meeting manufacturer’s specifications prior to placement of surface treatment.

D. Placement.

1. Mixture proportions are proprietary but must account for color and traffic use.
2. Thoroughly mix part ‘A’ (Resin) with part ‘B’ (Hardener) utilizing a suitable heavy duty electric paddle mixer or similar in amounts recommended by manufacturer.
3. Pre-wash and completely dry all aggregates and provide bagged materials consistent with the mixture proportions before batching and mixing.
4. Thoroughly mix aggregates and polyurethane binder mixture in the amounts recommended by manufacturer.
5. Apply, uniformly spread and finish surface between the grade control forms utilizing rubber squeegees and trowels as recommended by the manufacturer and as shown on the plans.
6. Imprint using an approved mold capable of providing a 3/8 inch to 1/2 inch deep imprint with the design details shown on the plans.
7. Use a manufacturer approved release agent to prevent imprinted material from sticking to the mold.
8. Provide a final texture and pattern shown on the plans.
9. Border the decorative crosswalk by installing two white parallel lines (minimum 6 inches thick) with a PennDOT approved pavement marking material that extends from face of curb to face of curb or edge of shoulder.
10. Remove all loose sand and clean entire surface area after Imprinting.
11. Do not allow vehicular traffic or loads on the system for a minimum of two hours from application or until the mixture is tack free.

IV. MEASUREMENT AND PAYMENT — Square Yard
I. DESCRIPTION — This work is the installation of manhole protection rings to provide a smooth graded transition of exposed manhole risers and collars to the pavement surface.

II. MATERIAL —
   A. Certification. MS-447A
   B. Thermoplastic.
      1. Publication 408, Section 965. This is a non-reflective, non beaded product; disregard sections related to glass beads. Disregard requirements for temperature and wind speed.

III. CONSTRUCTION —
   A. Preparing Existing Surface. Remove and dispose of all unsuitable material. Where necessary use a broom.
   B. Installation:
      1. Asphalt Pavements: Apply according to manufacturer recommendations. Apply at ambient and pavement temperatures above 32°F without any preheating of the pavement.
      2. Portland Concrete Pavements: Section III,(b)1. Except as follows: Apply a manufacturer recommended concrete sealer before installing thermoplastic rings.

IV. MEASUREMENT AND PAYMENT —
   A. Thermoplastic Manhole Protection Rings. Each
   B. Concrete Sealer. Tube, or Gallon
CERTIFICATE OF COMPLIANCE
BUREAU OF MUNICIPAL SERVICES
PLEASE TYPE OR PRINT IN BLUE OR BLACK INK ALL INFORMATION

A COPY OF THIS CERTIFICATION IS TO BE SENT TO THE PROJECT WITH EACH SHIPMENT OF MATERIAL DELIVERED. Maintain the original copy of this certification along with all component certifications in a file at the manufacturer’s, fabricator’s, or producer’s location. These files must be available for inspection and verification by a Department Representative for a period of not less than THREE years from the date of the last shipment.

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CONSIGNEE: (Contractor, Supplier, Fabricator, etc...)

I/WE HEREBY CERTIFY THAT: ____________________________________________________________

(Description of Material)

FURNISHED BY: ____________________________________________________________

(Name of Manufacturer, Fabricator, Producer or Supplier)

OR DISTRIBUTED BY: ____________________________________________________________

(Vendor, Broker, Supply House)

MEETS THE REQUIREMENTS OF PUBLICATION 447, SECTION: ____________________________ ITEM NUMBER: ____________________________

AND AASHTO, ASTM, FEDERAL OR OTHER DESIGNATION: ____________________________

LOT NUMBER/QUANTITY:

| CHECK HERE IF YOUR PRODUCT CONTAINS IRON OR STEEL, otherwise skip to the signature block. |
| I/ We certify that we received a copy of Mill Certification Form from the manufacturer of any steel or iron materials, including coatings application (e. g., epoxy, galvanizing, or painting) contained in our product certifying that all manufacturing processes have occurred in the United States and are maintaining copies, in our files in accordance with Publication 408 Section 106.03(b)3. |

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** While coating materials themselves are not covered by Buy America, the application of these materials on steel or iron must occur in the United States.