

CHAPTER 4 LIQUID THERMOPLASTIC

OBJECTIVES

- 1) Thermoplastic Material
- 2) Components
- 3) Material Characteristics
- 4) Application Methods
- 5) Application Considerations
- 6) Material Testing
- 7) Inspection and Quality Control

THERMOPLASTIC MATERIAL

Thermoplastic resin material has various uses, including being a durable pavement marking material. Thermoplastic is a blend of solid ingredients that become liquid when heated. It comes from the manufacturer intermixed with some reflective beads. When heated and properly agitated, the dry thermoplastic compound becomes a homogenized liquid. Reflective beads are intermixed and suspended in this liquid. Applied at the proper temperature, the thermoplastic melts into the upper surface of the HMA pavement forming a thermal bond. When applying thermoplastic to PCC, a primer/sealer from the thermoplastic manufacturer shall be used to ensure a proper bond to the surface.

Thermoplastic provides a visible, durable pavement marking because of its thickness and the use of intermixed and drop-on beads.

COMPONENTS

Thermoplastic resin marking is composed of pigment, reflective beads, filler, binder, and additives.

Pigment

Pigment is primarily used to impart color and to provide some chemical property, such as hiding or UV stability. Titanium dioxide is typically added to provide a white color and lead chromate or organic pigments are typically added to provide a yellow color. Because of environmental and health concerns, lead compounds in pavement marking material have been eliminated.

Reflective Beads

Thermoplastic is manufactured with a certain percentage of beads intermixed with the unmelted material. Additional beads are added to the surface of the applied line at a rate of 7-9 pounds per 100 square feet of marking material.

Filler

Fillers are pigments and are used to provide bulk. Once the necessary color and hiding has been obtained, fillers such as a mixture of calcium carbonate, sand, and other inert materials, are used to provide the needed volume adding durability, without the higher cost of the hiding pigments.

Binder

The binder is generally either hydrocarbon or alkyd. Generally, thermoplastic takes its name from the type of resin present. The hydrocarbon resin is made from petroleum-derived resins. The alkyd type is made from a naturally occurring resin. Both types of material are thermoplastic, they melt when heat is applied. Heat is used to form the initial shape and is also used to reform the shape. The material does not change chemically, but physically, during heating and application.

Additives

Additives like plasticizers are added to enhance rheological, or flow characteristics. Because the plasticizer can burn away, overheating and excessively reheating the thermoplastic can dramatically affect the quality of the line.

Solvent

There are no solvents in the traditional sense. The heating process transforms the thermoplastic material from a solid into a liquid.

MATERIAL CHARACTERISTICS

Two types of thermoplastics, hydrocarbon and alkyd, that exhibit different properties are used in pavement marking applications.

Hydrocarbon

- Relatively more heat stable than alkyd
- Exhibits predictable application properties
- Can break down under heavy oil drippings

Alkyd

- More resistant to deterioration from petroleum products
- Highly heat sensitive
- Requires great care during application
- May thicken if heated too long, causing it to become gummy and unstable, which will result in inconsistent markings

Manufacturers recommend that alkyd type material only be used if a new HMA surface will be marked in fewer than 10 days.

The manufacturer's application guidelines shall always be followed. Material formulations for extruded material are different than for spray material. The formulations are not generally interchangeable for each type of application. There are interchangeable formulations based on the method of application. It is important to verify that the proper and appropriate material is being used for the method of application.

Other factors that should be considered when using thermoplastics are packaging, shelf life, mixing materials, primers and priming, and material testing.

Packaging

Hydrocarbon and alkyd thermoplastic are available in either granular or block form. The granular material is usually packaged in 50-pound bags. All other product components have been physically mixed together, but not heated. Manufacturers recommend heating this material no more than 3 times before discarding. The bags may be heat degradable.

The standard package for block material is 50-pound boxes. Supplied in this form, the components have already been heated to mix them together. Since it's been heated once during production, manufacturers recommend heating this material no more than 2 additional times before discarding.

Shelf Life

Thermoplastics have a shelf life of one year when stored inside at a temperature less than 100°F. This must be considered when accepting the material for a project. Shipping documents are required to have the expiration or shelf life data printed on them.

Mixing Materials

Alkyd and hydrocarbon materials shall NOT be mixed. This applies to material in the melter equipment. If it is necessary to change from one type of material to the other, the melter shall be thoroughly cleaned first.

Primers and Priming

Primers are used as a "bridge" between thermoplastic and a surface where thermoplastic will not readily adhere. In other words, the primer bonds to the surface, and the thermoplastic bonds to the primer.

Some government agency specifications require the use of primer on all hydraulic cement concrete roadways. Manufacturers of thermoplastic recommend using a primer on HMA surfaces that are more than two years old, oxidized, and/or have aggregate exposed.

Primer must be applied to ensure adequate coverage, and must be allowed to cure according to manufacturer's instructions before applying thermoplastic. The primer must be from the same source as the thermoplastic material.

APPLICATION METHODS

There are three basic methods of applying liquid thermoplastic. These vary according to the type of device or gun that is used in applying the line to the roadway.

Spray Gun

This method of application is accepted in many states for all markings. It involves using a gun that is similar to that used in conventional paint application (i.e. the system is under pressure to deliver the material to the gun, and air is used to atomize the thermoplastic in the gun prior to its being forced out onto the roadway).

A major advantage of this method is that it is possible to go faster and cover rough surfaces with greater ease.

A major disadvantage of spraying is that going faster may result in heat loss of the material and may adversely affect the bond between the marking and the substrate. Also, the thickness of the applied line is more difficult to control than other application methods because it is directly affected by the speed of the applicator.

Screed / Extrusion Shoe

This method of application is typically used for legends, crosswalks, stop bars, etc. Thermoplastic material is forced through a die or shoe riding on the pavement surface. With gravity extrusion, the hot thermoplastic enters a trough or shoe that has a gate. The gate opening is set to produce the specified thickness as the material flows onto the pavement. Since the heat is maintained in the extrusion device, the bond remains consistent as long as the pavement surface is consistent. There are a number of extrusion devices that differ primarily in the inner workings of the shoe itself.

The major advantage of this method is that the material flows onto the pavement uniformly at the correct thickness. It's easy to get a well-defined line on most surfaces, and greater thickness can be achieved than with the spray method.

A major disadvantage is that on uneven surfaces, the material will flow out from the sides of the shoe, since the sides are used to contain the material. Also, the speed of application is much slower than that of the spray method.

Ribbon Gun

This method of application involves using a gun that rides just above the pavement surface. Material is forced through the system and into the gun, and from there it flows onto the pavement. This method is NOT accepted by all agencies.

A major advantage of this method is that it produces sharp edges and is easier to mark rough surfaces.

However, a major disadvantage is that it may go on too fast, causing too much heat loss, resulting in a poor bond.

APPLICATION CONSIDERATIONS

- **Bead distribution:** Reflective bead application should be uniform across the entire line. Check for proper volume, distribution, and embedment. Remember that material temperature and thickness can also affect bead embedment. The material guns must be synchronized with the bead guns to ensure that the entire surface area of the material is properly reflectorized.
- **Mixing:** Material should be agitated frequently.
- **Application temperature:** Changing ambient temperatures can affect application. Beware, wind chill may cool the gun. Raising the thermoplastic temperature to compensate for this may result in overheating that may char the material.
- **Material adhesion:** Thermal bonding is essential. After the material has cooled, the bond can be checked for adherence. Refer to the government agency or manufacturer specifications for this procedure.
- **Maximum heating time:** Total heating time must not exceed the material manufacturer's recommendations.
- **Maximum holding time:** Do not hold thermoplastic above 400°F for more than six hours.
- **Maximum temperature:** At no time shall the thermoplastic exceed 475°F. Care must be taken not to exceed the flash point indicated in the government agency or manufacturer specifications.
- **Maximum reheats:** Reheat granular thermoplastic a maximum three times, block two times. Color change indicates the material is overheated and beginning to scorch: white thermoplastic turns beige or creamy; yellow may become pale, or develop a brownish or greenish tint.
- **Cleaning:** Schedule the melter for cleaning if charred or burned particles remain on the screen during transfer. Completely flush the system when changing from alkyd to hydrocarbon or vice versa.
- Also, when changing from one color to another it is necessary to run several bags of the new color material through the entire system, and then discard. This will ensure that the newly applied marking is the proper color.
- **Operating tip:** Completely drain kettle before overnight shutdown whenever possible (this will aid in expediting the loading process for the next production day). Keep the kettle closed to protect from moisture and other contaminants.
- **Precautions:** Guard against temperature loss during transfer.
- **Safety tip:** Keep a cooler of ice water on the long-line or hand-line machine during application. In case of accidental contact with hot thermoplastic material, use the ice water to cool the affected area immediately. Follow the instructions on the Materials Safety Data Sheet or call a physician. **DO NOT ATTEMPT TO PULL THE HOT THERMOPLASTIC MATERIAL FROM THE AFFECTED AREA.**

MATERIAL TESTING

Quality Control/Quality Assurance (QC/QA) or acceptance testing will be as described in each government agency's materials testing specifications.

Derived quantities are based on 4-inch, 5-inch, and 6-inch wide lines using hydrocarbon material and will vary with material specific gravity, application methods, and pavement surface texture. Alkyd has approximately 2.5 percent less yield due to the specific gravity of the material.

The following chart contains a typical testing measure to determine thermal bonding and thickness. For additional accuracy, contact the thermoplastic manufacturer for their thermoplastic yields.

APPROXIMATE THERMOPLASTIC YIELDS						
	FOR A 4-INCH LINE		FOR A 5-INCH LINE		FOR A 6-INCH LINE	
mils	lf/lb	lb/mile	lf/lb	lb/mile	Lf/lb	lb/mile
SPRAY APPLICATION – DENSE GRADED SUBSTRATE						
40	7.5	704	6.0	880	5.0	1,056
60	5.0	1,056	4.0	1,320	3.33	1,584
90	3.375	1,564	2.7	1,956	2.25	2,347
SCREED/EXTRUSION – DENSE GRADED SUBSTRATE						
60	4.5	1,173	3.6	1,467	3	1,760
90	3.125	1,690	2.5	2,112	2.08	2,534
125	2.25	2,347	1.8	2,933	1.5	3,520
SCREED/EXTRUSION – OPEN GRADED SUBSTRATE						
60	3.75	1,408	3.0	1,760	2.5	2,112
90	2.75	1,920	2.2	2,400	1.83	2,880
125	2.125	2,485	1.7	3,106	1.42	3,727

Figure 4.1
Approximate thermoplastic yields

INSPECTION AND QUALITY CONTROL

A vital component of quality assurance is inspection and quality control before, during, and after application. Regardless of the method of installation, there are some absolutes that must be followed.

These factors must be addressed to achieve good application:

- Type of material being used and thickness of application
- Temperature of material during application
- Ambient and surface conditions
- Reflective bead rate, pattern, and embedment

Type of Material

The proper type of material (alkyd or hydrocarbon) must be used based on which application is being performed. Even if all the other factors are correct, they can never overcome the use of the wrong type of material. For example, hydrocarbon may not be the best choice when applying a stop bar at an intersection that has heavy truck traffic. The oil and gasoline drippings can break down the resin causing premature failure.

Material Temperature

Temperature is very important in the proper mixing, melting, and bonding of thermoplastic. Temperature guidelines must be followed. Most manufacturers recommend 420°F as the ideal material temperature. If the material is too hot or has been heated too long, it will be scorched, which affects bonding, durability, and color. Material must also be agitated properly in the melting tank while being heated so that the intermixed reflective beads do not settle, thus altering the composition of the applied line. Also, thermoplastic that is too cold will cause application and durability problems. If thermoplastic is too cold, it will not melt into the roadway resulting in a poor bond. Thermoplastic that is too cold will also prevent the reflective beads from embedding deep enough, resulting in accelerated bead loss and lower retroreflectivity.

Ambient Conditions

An air temperature of at least 55°F and rising is typically required. Windy conditions may affect ambient temperature and cause material displacement during application.

Pavement Surface Considerations

Pavement surface temperature shall be at least 55°F and rising. The pavement surface must also be clean and dry. Keep in mind that surface conditions may change as the applicator goes from sunny to shady areas. When installed on porous surfaces, hot liquid thermoplastic fills voids, creating a good mechanical bond. Larger quantities of material may be required to yield the minimum thickness since the hot material sinks into the voids. To ensure a good bond, the material should not be applied too quickly to avoid entrapping air. All grease, oil, dust, dirt, and debris must be removed prior to applying thermoplastic. In addition, on concrete surfaces, curing compounds and laitance must be removed. Primer sealer must be used on all concrete surfaces.

Moisture

If hot thermoplastic is applied over a moist surface, pits will appear in the line resulting in delamination. Thermoplastic shall not be applied if moisture is present on the road surface.

The following test may be conducted to determine if moisture is present. Method 1 or 2 can be used to test for moisture in pavement prior to installing thermoplastic; however, Method 2 is specific for thermoplastic.

Method 1: Tape an 18-inch square sheet of thin plastic to the road surface, being careful to seal all the edges. After 20 minutes, examine the bottom of the sheet and the road surface. If moisture is present, do not apply thermoplastic. Wait from 30 minutes to an hour and repeat the test until there is no moisture on the road surface or on the underside of the plastic.

Method 2: Securely tape tar paper to the road surface. Apply marking material to the tar paper. After 1 minute, carefully remove tar paper from road surface wearing work gloves. Examine the underside of the tar paper. If moisture is present do not apply thermoplastic. Retest after sufficient drying time.

Figure 4.2 is a troubleshooting guide for thermoplastic application problem.

THERMOPLASTIC APPLICATION TROUBLESHOOTING			
PROBLEM	CAUSE	EFFECT	REMEDY
Applied line appears Rough on surface and edges	<ul style="list-style-type: none"> Material not cured Material applied too cold 	<ul style="list-style-type: none"> Loss of durability Out of standards 	<ul style="list-style-type: none"> Raise material temperature Increase amount of material Decrease atomizing air pressure (if spray application)
Applied line is wavy with irregular edges	<ul style="list-style-type: none"> Material too hot Application pressure too high 	<ul style="list-style-type: none"> Poor reflectivity Poor appearance Poor durability 	<ul style="list-style-type: none"> Verify correct material for type of application
Line appears discolored, beige, or dingy (dull white)	<ul style="list-style-type: none"> Extrusion gate too wide or material flowing past gate Road surface uneven Material overheated or reheated too many times 	<ul style="list-style-type: none"> Does not meet color standard Material is brittle - low durability 	<ul style="list-style-type: none"> Adjust material temperature Lower application pressure Adjust application equipment/lower application rate Discard material
Line appears pitted	<ul style="list-style-type: none"> Trapped moisture Material not cured Trapped air 	<ul style="list-style-type: none"> Poor surface bond - low durability 	<ul style="list-style-type: none"> Stop operation until road dries Stop operation until primer cures Slow application to fill voids in open graded pavement

THERMOPLASTIC APPLICATION TROUBLESHOOTING-continued			
PROBLEM	CAUSE	EFFECT	REMEDY
Line appears lumpy	<ul style="list-style-type: none"> Charred material Unblended material 	<ul style="list-style-type: none"> Low durability 	<ul style="list-style-type: none"> If lumps appear burnt or dark in color, screen material to remove lumps. If lumps appear grainy or unmixed, hold material at 420°F until they dissolve.
Line appears stretched or pulled	<ul style="list-style-type: none"> Material applied too cold Material applied too fast 	<ul style="list-style-type: none"> Poor surface bond - low durability 	<ul style="list-style-type: none"> Raise temperature Lower speed of application
Line appears scarred or gapped	<ul style="list-style-type: none"> Charred material Dirt or debris on pavement surface 	<ul style="list-style-type: none"> Poor surface bond - low durability 	<ul style="list-style-type: none"> If lumps appear burnt or dark in color, screen material to remove lumps Clean pavement surface
Line appears uneven at beginning or end	<ul style="list-style-type: none"> Applicator not adjusted properly 	<ul style="list-style-type: none"> Poor appearance 	<ul style="list-style-type: none"> Adjust applicator
Line exhibits dribbles between skips	<ul style="list-style-type: none"> Applicator not adjusted properly 	<ul style="list-style-type: none"> Poor appearance 	<ul style="list-style-type: none"> Adjust applicator
Line marred by tire tracks	<ul style="list-style-type: none"> Opened to traffic too soon Insufficient reflective beads 	<ul style="list-style-type: none"> Poor reflectivity Poor appearance 	<ul style="list-style-type: none"> Keep traffic off longer Add more beads
REFLECTIVE BEAD PROBLEMS			
Line appears smooth, shiny, or glossy	<ul style="list-style-type: none"> No reflective beads 	<ul style="list-style-type: none"> No initial reflectivity 	<ul style="list-style-type: none"> Adjust or reposition bead gun Need more beads
Line appears smooth or dimpled	<ul style="list-style-type: none"> Beads have sunk too low 	<ul style="list-style-type: none"> No initial reflectivity 	<ul style="list-style-type: none"> Lower material temperature Reposition bead gun Increase bead application rate
Line appears glazed	<ul style="list-style-type: none"> Beads are not embedded properly 	<ul style="list-style-type: none"> Early loss of initial reflectivity 	<ul style="list-style-type: none"> Raise material temperature Reposition bead gun
Line appears cratered	<ul style="list-style-type: none"> Beads have popped out 	<ul style="list-style-type: none"> Low initial reflectivity 	<ul style="list-style-type: none"> Raise material temperature Reposition bead gun

Figure 4.2
Liquid thermoplastic troubleshooting

VIRGINIA DOT REFERENCES

See Appendix A for the following:

VIRGINIA ROAD & BRIDGE SPECIFICATION BOOK

Section 246.01 thru 246.02 (a) and (c)

- (a) Color Requirements
- (c) Thermoplastic Composition and Physical Requirements

Section 246.02 (g) 3. c.

- (g) Construction Pavement Marking Material
 - 3. Temporary Marking Material
 - c. All Products (Requirements as a Temp. Marking)

Section 704.01 thru 704.03 (a) 2. a.

704.01 thru 704.03 Description, Material Types, and Procedures

- (a) Pavement Markings
 - 2. Type B Markings
 - a. Thermoplastic (Class I)

See Appendix B for the following:

MANUAL OF INSTRUCTIONS

Section 204.30 (a) (1) and (2)

- (1) Sampling, Testing, and Approval
- (2) Acceptance (Requires Cert. I) Both white and yellow material are tested however, yellow thermoplastic formulations have been pre-tested to assure acceptable nighttime color. Approved List # 43 (Yellow Thermoplastic Only)

See Appendix C for the following:

VIRGINIA TEST METHOD

VTM-94 Quality Control Testing of Pavement Markings

Chapter 4

Liquid Thermoplastic Review Questions

1. Liquid thermoplastic pavement marking material:
 - a) is a blend of solid materials that becomes liquid when heated.
 - b) is just like paint.
 - c) is not allowed for pavement markings.
 - d) sets-up when a catalyst is applied.

2. Markings constructed with liquid thermoplastic pavement marking materials are considered:
 - a) durable markings.
 - b) non-durable markings.
 - c) none of the above

3. Liquid thermoplastic comes from the manufacturer with reflective beads already intermixed.
 - a) True
 - b) False

4. Reflective beads have to be applied to liquid thermoplastic pavement markings.
 - a) True
 - b) False

5. Granular thermoplastic may be heated three (3) times.
 - a) True
 - b) False

6. Block thermoplastic may be heated three (3) times.
 - a) True
 - b) False

7. It is permissible to intermix alkyd and hydrocarbon thermoplastic materials in the same heating kettle.
 - a) True
 - b) False

8. Which of the following methods are acceptable for applying thermoplastic?
- a) screed/extrusion shoe
 - b) ribbon gun
 - c) spray
 - d) all of the above
9. Virginia Road & Bridge Specifications requires the thickness of thermoplastic markings to be:
- a) 15 ± 1 mil when set
 - b) 90 ± 5 mils when set
 - c) 25 ± 5 mils when wet
 - d) 1/8 in when wet
10. Virginia specifies that glass beads be applied to the liquid thermoplastic immediately and uniformly across the entire line at the rate of:
- a) 7 lb/100 ft²
 - b) 10 lb/gal
 - c) 6 lb/gal
 - d) 25 lb/gal