CHAPTER 3 TRAFFIC PAINT

OBJECTIVES

1) Traffic Paint
2) Components
3) Reflective Beads
4) Characteristics of Waterborne Paint
5) Characteristics of Solvent Borne Paint
6) Application Considerations

TRAFFIC PAINT

Traffic paint is a thin layer of blended material. This chapter will describe waterborne traffic paint and solvent borne traffic paint. Reflective beads are added to the surface of the paint during application to produce nighttime retroreflectivity.

Thickness

Paint should be applied at 15±1 mil. 1 mil = 0.001 inch 15 mil = 0.015 inch

COMPONENTS

Paint is mainly composed of finely ground pigments that are mixed into a resin or binder system. Then various ingredients and additives are incorporated for certain desired properties. A liquid (water or solvent) is added to the mixture to produce a material that is pliable by application equipment. All of the ingredients/components in traffic paint are added specifically for one or more of the following functions: aiding the manufacturing process, increasing storage time in containers, easing application, and increasing durability once the paint has been applied.

Prime Pigments

Prime pigments are used to impart chemical properties such as UV stability, or physical properties such as color and hiding. Hiding is the ability of a paint to cover or block out the surface (substrate) beneath it. Titanium dioxide is typically used to make a white color. It is the primary pigment that gives traffic paint good hiding power.

Lead chromate was typically used to make a yellow color. However, due to health concerns with lead chromate pigments, organic pigments are now being used as a substitute for the lead chromate. Some types of pigments can be used interchangeably between solvent borne and waterborne traffic paint.

Extender Pigments

Once the necessary amount of prime pigment is added for hiding, less expensive extender pigments or fillers are used to bring the pigment level up to the required point. Extender pigments not only reduce cost, they give paint consistency, durability, permeability, and scrubability. These properties
are very important when considering the harsh environment and abuses that traffic paint must withstand. The main types of extenders are aluminum silicate (china clay), calcium carbonate, calcium sulfate, and magnesium silicate.

**Resins or Binders**

The resin is the component that bonds the pigment and beads together. It also provides the adhesion to the road surface. The resin is the binder or glue in paint.

Waterborne paints typically use three types of resins. They are polyvinyl acetate latex, methylmethacrylate, or a one-hundred-percent acrylic resin. These materials are pre-reacted and put into solution using emulsifiers. These emulsions are materials that normally do not mix. Once the paint has been applied, it must allow the water to evaporate in order for the paint to “break” and adhere to the roadway. This settling is generally called coalescence. One-hundred-percent acrylics are used predominantly due to faster “no track” times and less heat needed during application.

Because of high humidity, waterborne paint will take longer to dry. Therefore, on low humidity days, waterborne paint will dry much faster. When there is less water in the air, the water can leave the film or evaporate much faster.

Solvent borne paints are typically linseed or soya oils and alkyd resins. These paints cure by solvent evaporation and the resin reacts with atmospheric oxygen to create a solid bond to the pigments, beads, and road surface. Some types of solvents used in these paints are naphtha, toluene, methanol, methylene chloride, and acetone. They are added to thin the paint out and make it easier to handle and spray.

Both waterborne and solvent borne paint resins have a critical value for the quantity of material that the resin can hold. This is called the critical-pvc pigment volume concentration. If this concentration is exceeded, the resin will not be able to bind the pigment and beads. This could also affect adhesion to the road surface.

**Solvents**

With waterborne paint, the water is more of a diluent rather than a solvent. It holds the resin emulsion in solution with the other components until the paint has been applied. Fast-dry waterborne paints may contain ammonia and/or methanol. Ammonia and methanol are Volatile Organic Compounds (VOCs). These VOCs accelerate the curing process throughout evaporation.

In solvent borne paints, the evaporation rate is very important. Because of this, they need to be tailored to leave the film at the right time. When solvents evaporate too fast, the surface can skim over and trap the rest of the solvents within the film. Most solvent blends keep the film open while solvents escape. That is why, as a general rule, just any solvent will not work.

Heat can be considered as a solvent for both waterborne and solvent borne traffic paint because it can be used to make paint more fluid and aid in evaporation.
Volatile Organic Compounds evaporate in the air. The Environmental Protection Agency (EPA) was mandated to establish VOC emission controls for “all field applied coatings.” The Clean Air Act Amendment (CAA) of 1990 designated these controls as “architectural coatings.”

This category is very broad ranging from interior house paints to heavy-duty industrial maintenance coatings. Different VOC limits were established according to the intended use of the coatings. Traffic Marking Coating VOC limits were set at 1.25 lbs/gal. This is the result of the EPA’s effort to reduce ozone, which is a significant ground level health hazard. A few materials, acetone and some special chlorinated solvents, have been declared exempt from these regulations because they don’t increase ozone levels. From a 1990 nationwide baseline, the annual reduction of VOC emissions is 10,600 tons.

**Additives**

Additives are included in paint to help prevent problems. One example is an anti-foam agent, which keeps paint from foaming during the high-speed mixing process. Other additives help prevent the paint from freezing, settling, or skimming in the drum. Additives usually only make up 0.1 to 5 percent of the paint. Some have a single function and others may have multiple functions. For example, ammonia acts as an accelerator for drying and keeps the pH level up in waterborne paint while being stored. It is important to maintain the pH level at 9.5 or higher to ensure the latex remains suspended in solution.

**REFLECTIVE BEADS**

A separate gun adds reflective beads to the wet paint at the time of application. Some agencies may also require the premixing of beads into the paint prior to application.

Reflective beads for painted markings are typically applied under pressure. This is necessary for the beads to achieve the proper embedment in the paint before its fast drying nature causes it to form a surface skin. The bead supply tank is pressurized to force the beads through the system to the bead gun. Since the system is under pressure and is not loaded in a vacuum, moisture can condense inside the tank and cause clogging problems. For this reason, the manufacturer usually adds a moisture-proofing agent. Beads are typically applied at a minimum rate of 6 pounds of beads per gallon of paint.
Beads are generally shipped in 50-pound bags with 40 bags shrink-wrapped on a pallet. They may also be shipped in 2,000-pound boxes.

**CHARACTERISTICS OF WATERBORNE PAINT**

There are many disadvantages and advantages to using waterborne paints for pavement markings. One major disadvantage of waterborne paint is its sensitivity to temperature. Precautions must be taken to protect stored material from freezing and extreme heat. During application, latex paint is very sensitive to high humidity, which can drastically increase drying time. Conversely, low humidity creates a quicker drying time. Paint is also the least durable of all the markings and is not recommended for roadways with high traffic volumes.

Some advantages of waterborne paint are cost. It is the least expensive of all pavement markings. It can be applied at a faster rate than most other markings and under ideal conditions it can have a very fast dry time. Also, no solvents are needed for clean up. Fast dry waterborne paint will achieve its best drying times under perfect ambient conditions: daytime, sunny, 70°F, low humidity and a breeze.

Some characteristics of waterborne paint are:
- Heat sensitivity
- Freezes easily
- Strong ammonia odor
- Humidity may affect drying times
- Can be flushed out with water and/or ammonia
- Generally not a hazardous waste for disposal - placarding not required (dependant on formulation)
- Reacts adversely to metals other than stainless steel
- Requires specially lined drums to prevent chemical reaction
- Can settle in the drum

**CHARACTERISTICS OF SOLVENT BORNE PAINT**

Some characteristics of solvent borne paint are:
- Humidity generally not an application problem
- Heat exchanger can be heated higher to assist in drying times
- Can film form at lower temperatures than waterborne
- Solvent blend critical to prevent skimming
- Requires placarding of vehicle
• Clean up flush material is hazardous waste
• Unused paint is hazardous waste for disposal purposes
• Can be very flammable
• Can easily settle in drum

Traffic paint is a one-component material that is generally shipped in 55-gallon drums with full open top lids. Traffic paint generally has a shelf life of one year. This information should appear on the shipping documents. Quality assurance tests may be performed to confirm that the original formulation is approved by the government agency and to verify the manufacturer’s certification.

No paint forms a film well when applied at low temperatures.

APPLICATION CONSIDERATIONS

Traffic paint is applied by conventional or airless spraying.

Conventional
Conventional spraying uses air jets in the tip of the paint gun to break up, or atomize the paint. The tip then defines the shape of the spray to produce a properly applied line. The quantity of atomizing air needed to sufficiently break up the paint will depend to a large extent on the paints rheology, or flow characteristics.

The pressure needed to force the paint through the application system and out of the gun can vary from 60 to 140 psi, depending on the size of the plumbing and the type of spray gun used. This can be achieved using one of the following methods:

• In a pressure-pot system, the holding tank is pressurized to push the paint through the heat exchangers and lines to the gun for application.
• In a pumper system, the holding tank is not pressurized. A diaphragm pump is used to draw the paint from the tank and force it through the system and out to the gun.

Airless

In an airless system, the paint is forced out through an orifice in the tip of the gun at a high pressure. The size of the hole determines how much paint is applied and the angle of the inner surfaces of the tip determines the width. Unlike the conventional system, there is no air mixed with the paint in the gun. The pressure created by the pump mechanism explosively forces the paint through the gun tip breaking the paint up into very small particles. The primary method for altering the width and thickness of the applied line is to change the tip. Chapter 11 shows a picture of a long liner truck.
Additional factors must also be considered when applying traffic paint:

**Material Temperature**
The manufacturer’s Product Data Sheets specifies the material application temperature ranges. Fast-dry (ammoniated), waterborne paint only needs enough heat to allow a good flow of material through the application system (generally in the range of 90 °F to 120 °F at the gun tip).

It is very important not to overheat the solvent or waterborne traffic paint because they can ignite. Overheating fast dry, waterborne paint can also “drive off” the methanol and ammonia creating longer dry times. These two additives act as driers to keep the paint film open, helping the water escape.

**Ambient Conditions**
Waterborne paint requires liquids to evaporate. This evaporation is dependent on the humidity (moisture in the air). Humid days will cause drying problems. Lower humidity and good air movement greatly improves waterborne materials drying. To achieve the optimal results, neither solvent nor waterborne traffic paint shall be applied below 50 °F (air temperature).

**Pavement Surface Considerations**
The pavement shall be free of dirt, oil, grease, laitance, curing compounds, and moisture. On new HMA pavements, paint may dissolve road oils and cause a discoloration of the line. This line should be repainted as soon as it has dried in order to achieve the proper color.

**Quality Assurance Field Testing**
Quality assurance field-testing shall be conducted in accordance with agency specifications.
<table>
<thead>
<tr>
<th>Problem</th>
<th>Cause</th>
<th>Effect</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excessive Thickness</td>
<td>- Paint tank pressure too high.</td>
<td>- Buried beads- poor initial nighttime retroreflectivity.</td>
<td>- Reduce tank pressure.</td>
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<tr>
<td>(overall)</td>
<td>- Paint gun volume control (if present) open too wide.</td>
<td>- Slow drying time-paint tracked by motorists.</td>
<td>- Adjust paint gun volume control.</td>
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<td></td>
<td>- Pump pressure too high.</td>
<td>- Paint won’t cure properly giving it a shortened life.</td>
<td>- Reduce pump pressure.</td>
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<tr>
<td></td>
<td>- Applicator speed too low.</td>
<td></td>
<td>- Increase speed.</td>
</tr>
<tr>
<td>Excessive Thickness</td>
<td>- Paint tank pressure too high.</td>
<td>- Buried beads – poor initial nighttime retroreflectivity.</td>
<td>- Reduce tank pressure.</td>
</tr>
<tr>
<td>(middle of line)</td>
<td>- Paint gun volume control (if present) open too wide.</td>
<td>- Slow drying time – paint tracked by motorists.</td>
<td>- Adjust paint gun volume control.</td>
</tr>
<tr>
<td></td>
<td>- Pump pressure too high.</td>
<td>- Paint won’t cure properly – shortened life.</td>
<td>- Reduce pump pressure.</td>
</tr>
<tr>
<td></td>
<td>- Atomizing air pressure off or too low.</td>
<td></td>
<td>- Increase atomizing air pressure.</td>
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<tr>
<td></td>
<td>- Material buildup in paint gun tip and/or shroud.</td>
<td></td>
<td>- Clean paint tip and/or shroud.</td>
</tr>
<tr>
<td>Excessive Thickness</td>
<td>- Material buildup in paint gun tip and/or shroud.</td>
<td>- Buried beads-poor initial nighttime retroreflectivity.</td>
<td>- Clean paint tip and/or shroud.</td>
</tr>
<tr>
<td>(along one side)</td>
<td>- Clogged hole(s) in paint gun atomizing tip.</td>
<td>- Slow drying time – paint tracked by motorists.</td>
<td>- Clear clogged hole(s) in paint gun atomizing tip.</td>
</tr>
<tr>
<td>Insufficient Thickness</td>
<td>- Paint tank pressure too low.</td>
<td>- Poor line quality and/or shortened life.</td>
<td>- Increase tank pressure.</td>
</tr>
<tr>
<td></td>
<td>- Paint gun volume control (if present) not open enough.</td>
<td>- Beads won’t adhere and/or poor or no nighttime retroreflectivity.</td>
<td>- Adjust paint gun volume control.</td>
</tr>
<tr>
<td></td>
<td>- Pump pressure too low.</td>
<td></td>
<td>- Increase pump pressure.</td>
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<tr>
<td></td>
<td>- Applicator speed too low.</td>
<td></td>
<td>- Decrease speed.</td>
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<tr>
<td></td>
<td>- Atomizing pressure too high.</td>
<td></td>
<td>- Decrease atomizing air pressure.</td>
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<tr>
<td></td>
<td>- Material buildup in paint gun tip and/or shroud.</td>
<td></td>
<td>- Clean paint gun tip and/or shroud.</td>
</tr>
<tr>
<td></td>
<td>- Material buildup in paint filter(s) and/or plumbing.</td>
<td></td>
<td>- Clean paint filter(s) and/or plumbing.</td>
</tr>
<tr>
<td>Paint Line Not Drying</td>
<td>- Surface temperature too cold.</td>
<td>- Vehicle tracking markings.</td>
<td>- Cone markings.</td>
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<td></td>
<td>- Material overheated.</td>
<td>- Tracked marking no longer has required retroreflectivity.</td>
<td>- Reduce material temperature.</td>
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<td>- High humidity.</td>
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<td>- Stop applying markings until environment improves.</td>
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<td></td>
<td>- Material past shelf life.</td>
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<td>- Check surface temperature.</td>
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<td>- Check age of material.</td>
</tr>
<tr>
<td>Problem</td>
<td>Cause</td>
<td>Effect</td>
<td>Remedy</td>
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<tr>
<td>Wide Paint Line</td>
<td>- Paint gun set too high. - Worn or damaged paint gun tip and/or shroud.</td>
<td>- Line does not meet standards. - Line has fuzzy edges.</td>
<td>- Lower gun. - Repair or replace tip and/or shroud.</td>
</tr>
<tr>
<td>Narrow Paint Line</td>
<td>- Paint gun too low. - Paint gun tip slot not at 90° angle to paint line. - Clogged paint gun tip and /or shroud. - Low air pressure in paint machine tire.</td>
<td>- Line does not meet standards. - Not as visible as a full – width line (day or night).</td>
<td>- Raise paint gun. - Reposition paint gun tip. - Clean paint gun tip and/or shroud. - Inflate tire.</td>
</tr>
<tr>
<td>Uneven Paint Line (spotty)</td>
<td>- Atomizing air pressure too low. - Paint tank pressure too low. - Old paint (viscosity too high). - Loose paint gun tip and/or shroud. - Insufficient heat. - No shroud.</td>
<td>- Poor appearance. - Line has fuzzy edges. - Slow drying time. - Paint won't flow smoothly.</td>
<td>- Increase atomizing air pressure. - Increase material tank pressure. - Rotate material stock. - Secure paint gun tip and/or shroud. - Increase heat (enough to get paint to flow evenly). - Install shroud.</td>
</tr>
</tbody>
</table>

**Figure 3.1**
REFERENCES

See Appendix A for the following:

**VDOT ROAD & BRIDGE SPECIFICATIONS BOOK**

Section 704.01 thru 704.03 (a) 1.
704.01 thru 704.03 Description, Material Types, and Procedures
   (a) Pavement Markings
      1. Type A Markings

See Appendix B for the following:

**VDOT MANUAL OF INSTRUCTIONS**

Section 204.30 (a) (1) and (2)
   (1) Sampling, Testing, and Approval
   (2) Acceptance (Requires Cert. I)

      Approved List # 20

See Appendix C for the following:

**VIRGINIA TEST METHOD**

VTM-94 Quality Control Testing of Pavement Markings
Chapter 3
Traffic Paint
Review Questions

1. VDOT designated “Type A” traffic paint should dry “track-free within:
   a) 5 minutes
   b) 2 minutes
   c) 60 seconds
   d) 30 seconds

2. Reflective beads are normally:
   a) added to the paint before it is applied to the roadway.
   b) spray applied to the wet paint immediately following application of the marking material.
   c) hand tossed into the marking.
   d) applied after the marking has dried.

3. The minimum surface temperature at which Virginia designated Type A traffic paint may be applied is:
   a) 30 °F +
   b) 45 °F +
   c) 50 °F +
   d) 60 °F +

4. Before marking materials of any kind are applied, the surface of the roadway must be:
   a) clean.
   b) dry.
   c) both a & b
   d) none of the above

5. The specified application thickness for Virginia designated Type A traffic paint is:
   a) 90 ±5 mils when set
   b) 20 ±2 mil when wet
   c) 15 ±1 mil when wet
   d) 12 ±3 mil when wet

6. The minimum amount of glass beads to be applied to Type A paint is:
   a) 6 pounds per gallon
   b) 25 pounds per gallon
   c) dependant on bead gradation
   d) dependant on environmental conditions
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 Hot Mix Asphalt (HMA) pavement forming a thermal bond. When applying thermoplastic to Portland Cement Concrete (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 pounds per 100 square feet (300 linear feet for 4 inch markings) 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.

<table>
<thead>
<tr>
<th>Approximate Thermoplastic Yields</th>
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<tbody>
<tr>
<td>FOR A 4-INCH LINE</td>
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<td>-------------------</td>
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<tr>
<td>mils</td>
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<td>40</td>
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<td>60</td>
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<td>90</td>
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<tr>
<td>Spray Application – Dense Graded Substrate</td>
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<td>90</td>
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<td>125</td>
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<td>Screed/Extrusion – Dense Graded Substrate</td>
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<tr>
<td>90</td>
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<tr>
<td>125</td>
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<td>Screed/Extrusion – Open Graded Substrate</td>
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</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>125</td>
</tr>
</tbody>
</table>

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 50°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 6 inch by 6 inch 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.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Cause</th>
<th>Effect</th>
<th>Remedy</th>
</tr>
</thead>
</table>
| Applied line appears rough on surface and edges. | - Material not cured  
- Material applied too cold. | - Loss of durability  
- Out of standards | - Raise material temperature.  
- Increase amount of material.  
- Decrease atomizing air pressure (if spray application). |
| Applied line is wavy with irregular edges. | - Material too hot.  
- Application pressure too high.  
- Extrusion gate too wide or material flowing past gate.  
- Road surface uneven. | - Poor reflectivity  
- Poor appearance  
- Poor durability | - Verify correct mat’tl for type of application.  
- Lower pressure application.  
- Adjust application equipment/lower application rate. |
| Line appears discolored, beige, or dingy (dull white). | - Material overheated or reheated too many times. | - Does not meet color standard.  
- Material is brittle - low durability. | - Adjust material temperature.  
- Discard material. |
| Line appears pitted. | - Trapped moisture  
- Material not cured  
- Trapped air | - Poor surface bond - low durability. | - Stop operation until road dries.  
- Stop operation until primer cures.  
- Slow application to fill voids in open graded pavement. |

Figure 4.2 Liquid thermoplastic troubleshooting
### Thermoplastic Application Troubleshooting - Continued

<table>
<thead>
<tr>
<th>Problem</th>
<th>Cause</th>
<th>Effect</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line appears lumpy</td>
<td>- Charred material</td>
<td>- Low durability</td>
<td>- If lumps appear burnt or dark in color, screen mat'l to remove lumps.</td>
</tr>
<tr>
<td></td>
<td>- Unblended material</td>
<td></td>
<td>- If lumps appear grainy or unmixed, hold material at 420°F until they dissolve.</td>
</tr>
<tr>
<td>Line appears stretched or pulled</td>
<td>- Material applied too cold.</td>
<td>- Poor surface bond - low durability</td>
<td>- Raise temperature.</td>
</tr>
<tr>
<td></td>
<td>- Material applied too fast.</td>
<td></td>
<td>- Lower speed of application.</td>
</tr>
<tr>
<td>Line appears scarred or gapped</td>
<td>- Charred material</td>
<td>- Poor surface bond - low durability</td>
<td>- If lumps appear burnt or dark in color, screen material to remove lumps.</td>
</tr>
<tr>
<td></td>
<td>- Dirt or debris on pavement surface.</td>
<td></td>
<td>- Clean pavement surface.</td>
</tr>
<tr>
<td>Line appears uneven at beginning or end. Or line exhibits dribbles between skips.</td>
<td>- Applicator not adjusted properly</td>
<td>- Poor appearance</td>
<td>- Adjust applicator</td>
</tr>
<tr>
<td>Line marred by tire tracks</td>
<td>- Opened to traffic too soon.</td>
<td>- Poor reflectivity - Poor appearance</td>
<td>- Keep traffic off longer.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Add more beads.</td>
</tr>
</tbody>
</table>

### Reflective Bead Troubleshooting

<table>
<thead>
<tr>
<th>Problem</th>
<th>Cause</th>
<th>Effect</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line appears smooth, shiny, or glossy</td>
<td>- No reflective beads.</td>
<td>- No initial reflectivity</td>
<td>- Adjust or reposition bead gun</td>
</tr>
<tr>
<td></td>
<td>- Insufficient reflective beads.</td>
<td></td>
<td>- Need more beads</td>
</tr>
<tr>
<td>Line appears smooth or dimpled</td>
<td>• Beads have sunk too low</td>
<td>• No initial reflectivity</td>
<td>• Lower material temperature</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Reposition bead gun</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Increase bead application rate</td>
</tr>
<tr>
<td>Line appears glazed</td>
<td>• Beads are not embedded properly</td>
<td>• Early loss of initial reflectivity</td>
<td>• Raise material temperature.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Reposition bead gun</td>
</tr>
<tr>
<td>Line appears cratered</td>
<td>• Beads have popped out</td>
<td>• Low initial reflectivity</td>
<td>• Raise material temperature.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Reposition bead gun</td>
</tr>
</tbody>
</table>
REFERENCES

See Appendix A for the following:

**VDOT ROAD & BRIDGE SPECIFICATION BOOK**

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