Thermoplastic Field Guide

Thermoplastic is a pavement marking material that is a 100% solid, environmentally and user safe compound. A mixture of glass beads, pigments, binder, and filler materials, thermoplastic, as its name suggests, becomes liquid when heat is applied.

Glass beads - provide the retroreflectivity necessary for its bright night time appearance

Pigments - provide the color and opacity

Binder - a mixture of plasticizer and resins that provide toughness, flexibility, and bond strength while holding all the components together

Fillers - such as calcium carbonate, sand and/or other inert substances that provide bulk

Thermoplastic Types:

Two basic types of thermoplastic are available. The two, *hydrocarbon* and *alkyd*, take their names from their binder types. **Hydrocarbon thermoplastic** is made from petroleum-derived resins.

- Hydrocarbon tends to be more heat stable, with more predictable application properties, than alkyd
- Because it tends to break down under oil drippings and other automobile contaminants, hydrocarbon is recommended for long-line, skip lines and edge-line applications and not for high-traffic areas where cars are stationary.(Such as stop bars , crosswalks, turn arrows)

Alkyd thermoplastic is made from wood-derived resins that is resistant to petroleum products. Alkyd thermoplastic exhibits some advantages over hydrocarbon materials such as:

- higher retroreflective values
- being oil impervious
- being more durable

Alkyd is recommended for inner-city markings and other high-traffic areas where petroleum drippings are common.

Both hydrocarbon and alkyd thermoplastic are available in granular or block form, packaged in 50-pound bags or boxes. The application properties of each should have a guaranteed shelf life of one year when stored inside at a temperature less than 100^0 F.

Hot applied thermoplastic is prepared for road application in a melting kettle where the granular or block material is introduced and heated until it liquefies at temperatures exceeding 400^0 F. An agitator blends the ingredients until thermoplastic is transferred into a screed, ribbon or spray device where it is then shaped into its specified width and thickness as a line, legend or symbol. Glass beads are immediately applied to provide initial retroreflectivity.

When applied on asphaltic surfaces, thermoplastic material develops a thermal bond via heat-fusion. When applied on Portland Concrete Cement and on oxidized or aged asphaltic surfaces, and a recommended sealer is properly applied, a tenacious mechanical bond is achieved.

Providing that all necessary conditions are met concerning temperature of material and substrate, absence of moisture, road preparation and minimum thickness, you can achieve excellent performance using thermoplastic pavement marking compounds. Typical performance life ranges from 4 to 8 years depending on roadway conditions.

Correct application of thermoplastic:

Temperature is the most important factor in the proper mixing, melting and bonding of thermoplastic.

- Heated to a temperature between 400 and 440^0 F and agitated properly, the thermoplastic compound becomes a homogenized liquid.
- Applied at this temperature, the thermoplastic melts into the upper surface of the asphalt, forming a thermal bond.
- When installed on porous surfaces, such as open-graded asphalt or tined concrete, the hot liquid thermoplastic fills all voids, creating a good mechanical lock on concrete .

Thickness of the applied thermoplastic should be as specified. A minimum thickness of 90 mils is important to the material's ability to hold the heat necessary for good bonding. The thermal bonding that occurs when application is at the proper thickness ensures the thermoplastic's durability and long-term retroreflectivity. A minimum thickness of 30 mils is required to hold the heat necessary for proper bonding when recapping a line because of poor reflectivity or inadequate thickness.

Being raised above the road surface, combined with the retroreflectivity produced by the glass beads, makes thermoplastic more visible from a distance and at night. The thickness also contributes to improved retroreflective performance in wet conditions and the exceptional durability of the product.

The amount of glass beads, both mixed in with the compound and dropped on the installed line, must be correct.

- Drop-on beads must be applied evenly and adhered to a depth of 50 to 60%.
- Apply at 8 to 10 lbs / 100 ft2.
- Proper application thickness, temperature and formulation, in conjunction with correct bead coatings, ensure that bead depth is accurate.
- Intermix beads shall be mixed in the thermoplastic in accordance with agency's specification.

Equipment:

Application equipment should meet the criteria of the specification. The engineer may be responsible for approving such equipment, whether it be mobile or portable, prior to the start of work.

Melting Kettle(s*)* must be capable of :

- Heating thermoplastic material to its application temperature evenly, without scorching.
- Maintaining temperatures above 400^0 F. The heating mechanism of the kettle should employ a heat transfer medium consisting of oil or hot air.
- A temperature gauge must be visible on the outside of the kettle to indicate the temperature of the thermoplastic material. The material gauge must not be confused with the heat transfer medium (oil temperature) gauge.

- Material temperatures should be monitored frequently with an external, calibrated thermometer. **Proper application temperatures should always be checked at the point of application.**

Mixing and Agitating Equipment - Melting kettles and portable applicators:

- Must be equipped with material agitators.
- Must be capable of thoroughly mixing the material at a rate which will ensure even disbursement and uniform temperatures throughout the material mass.

Priming Equipment

On pavement surfaces that are to be primed before the application of the thermoplastic material, the primer material shall be sprayed on the surface at the specified rates recommended by the manufacturer of the primer/sealer material. All of the priming equipment should be inspected and checked to ensure that it is completely operational and capable of disbursing the primer/sealer at the rate prescribed by the manufacturer.

Glass Bead Dispenser

Both mobile and portable thermoplastic application equipment are required to be equipped with a drop-on or a pressure-type bead dispenser. The glass beads are to be evenly dropped-on to the hot thermoplastic stripe immediately after its application, embedding and anchoring at a depth of 50 to 60%. The purpose of the glass beads is to provide initial night time retroreflectivity of the pavement marking which, without them, would be barely visible to the motorist. The bead dispenser shall be inspected frequently to ensure proper operation and to ensure uniform rates of each application over the entire marking surface.

Dispensing Devices

There are various devices used to screed/extrude thermoplastic material onto the pavement. The device should be positioned such to protect it from the wind.

- ***Ribbon Dispensers*** are heated and suspended above the road surface, applying a forced-extrusion, well-defined thermoplastic line.
- ***Spray Dispensing Devices*** - Thermoplastic spray pattern shall result in a uniformly thick, well-defined and securely-bonded stripe as specified. Compressed air must be dry when mixing with the molten thermoplastic.
- ***Screed Extrusion Devices*** - The dispensing shoe rides directly on the road surface and a continuos line is formed by a three sided die with a control gate set to a pre-determined thickness.

Successful Performance:

Because bond failures are application related, they can be minimized by proper application controls. This can be accomplished through correct and frequent inspection at the project site. The following guidelines are intended to assure successful installation performance.

Marking Location - To minimize damage from snowplow blades and from substrate failure, thermoplastic markings must be:

- placed directly on the lane, preferably 2 inches from the shoulder and construction joints.
- Do not apply edgeline markings directly over the joint formed between the roadway and the adjoining shoulder.
- Do not apply skip line markings over the longitudinal joint between travel lanes.

Equipment - A daily inspection of equipment should be made to ensure that is operable and within the specification requirements. Breakdowns of equipment during the day may cause thermoplastic materials or primers to be subsequently held too long or heated improperly. This can result in parts of the job failing to meet the overall specifications and longevity requirements of the road marking material. Intermittent malfunctions of equipment can also cause inconsistent performance of small sections of lane lines within a limited area. Continuous uniform operation of all equipment used to make thermoplastic applications is of extreme importance. Keep equipment clean and free of material residue buildup.

Materials - Material specifications should be reviewed completely. It is the function of the government testing laboratory to determine whether or not the material meets the requirements of the material specifications. Field samples of material may be retained by the project engineer for quality verification.

Material packaging shall have accurate batch number designations. The material type and formulation should be distinctively shown on the container: 1) Alkyd or Hydrocarbon and 2) Extrude or Spray.

Although alkyd and hydrocarbon materials will fuse to one another on the road, they are incompatible in a melting kettle. Failure to completely clean out kettles during material change-overs can cause severe equipment problems. DO NOT MIX ALKYD AND HYDROCARBON MATERIALS!!!

Pavement Surface - Pavement surfaces must be clean, dust free and dry. Remove poorly adhering, existing markings and curing compounds. Air and surface temperatures shall be at least 50^0 F and rising during applications.

Heavy deposits of existing painted pavement markings, polymer traffic tapes, and built-up roadside accumulations of dirt, etc., will all require removal. In some cases, an air blast or manual or mechanical brooming will be sufficient to clean the surface. In others, more effort or different methods such as abrasive-blasting, water blasting or mechanical removal will be needed.

New thermoplastic applications should successfully bond to worn existing thermoplastic lines or preform thermoplastic markings. Do not apply thermoplastic over existing tape markings.

All pavement should be more than visibly dry. Moisture is the most detrimental factor in bonding. Subsurface moisture can be present in amounts sufficient to affect proper bonding. Early morning dew and fog conditions will usually cause dampness. If excess pavement moisture exists, it will usually result in blistering the hot-applied marking. Blisters will form as surface bubbles which may or may not have burst open. They are easily spotted, and if the condition occurs, marking operations should be stopped until the pavement dries. The only way to be certain whether moisture is present is to conduct a test. There are numerous ways to test for moisture.

- Tape a 12 inch square sheet of thin plastic to the road surface, being careful to seal all edges. After 15 minutes, examine the bottom of the sheet and the road surface. If more than a sparse amount of moisture is present, do not apply thermoplastic.
- Place an 18 inch piece of tar paper on pavement and apply thermoplastic heated to 420^0 F on top. Wait two minutes and lift tar paper. Check underside. If moisture is present, do not apply.

Air Temperature - Thermoplastic should only be applied if the air temperature is 50 F and rising. Be sure to account for wind chill factors. If the temperature falls below 50 F, then striping operation should be halted.

Primer Application - Use the thermoplastic manufacturer's recommended primer:

- on all Portland concrete
- on asphalt surfaces that are more than two years old, oxidized and/or have aggregate exposed

If specified prior to the thermoplastic application, the primer must be applied to all pavement surfaces at manufacturer's recommended application rates. It must set for the specified cure or evaporation time prior to thermoplastic being applied.

Primed pavement surfaces must be striped within the specified set time or within the same working day. If the primed surfaces are not striped within these time limits, they must be reprimed prior to the thermoplastic application at the prescribed rate denoted by the manufacturer. If an approved epoxy primer is used, proportional mixing must be checked and thermoplastic application must occur before epoxy has cured.

Improper primer/sealer application will cause bond failure between the thermoplastic and substrate. Improper application may also result in physical degradation of the thermoplastic material by excessive pinholing and blistering of the line. This degradation may occur through extraction of the binder by the solvent system contained in the primer/sealer promoted by improper drying time and application rates.

Thermoplastic Application - The thermoplastic striping material must be applied onto the pavement surface at a material temperature range between 400^0 F to 440^0 F depending on ambient weather conditions. Material temperature is measured preferably at the point of road contact.

Drop-on glass beads must be immediately mechanically deposited after applying the thermoplastic line. If the glass beads are not adhering to the thermoplastic line, all operations should immediately be suspended until the problem can be corrected. Drop-on beads anchor and reflect best at 50-60% embedment

Applying thermoplastic at proper application temperature (400^0 F+) is the most critical factor affecting the bond to the substrate. If the road temperature is 50^0 F, then the recommended application temperature for the thermoplastic striping is 440^0 F. If the road temperature is at 77^0 F, the thermoplastic material may be applied at a lower temperature.

Applications on Portland cement surfaces should always exceed 425^0 F in order to maximize penetration and bond strength.

The thermoplastic material temperature in the kettles, applicators, or exiting dispensing device, can be verified with a noncontact infrared thermometer.

Discrepancies of 10^0 F may be tolerated, but in no case should a 10^0 F discrepancy be tolerated if this shows as 10^0 F below the minimum recommended application temperature.

Preheater/melter operation

- Calibrate material temperature gauges periodically (weekly is suggested) by using a reference thermometer
- Fill melter to 30% capacity. When thermoplastic is liquefied, add remaining material gradually to fill melter to capacity.
- Transfer thermoplastic 30 minutes after its temperature reaches 400^0 F. During transfer, thermoplastic should pass through a one-quarter inch mesh screen.

- Add more thermoplastic when two-thirds of the liquefied material has been used. The material is ready again for transfer 30 minutes after reaching 400^0 F.
- Cease agitation during cool-down after the thermoplastic's temperature cools to 300^0 F.

Important preheater/melter considerations

- Maximum holding time: Do not hold thermoplastic above 400^0 F for more than six hours.
- Maximum temperature: The thermoplastic should not exceed 450^0 F.
- Maximum reheats: Reheat granular thermoplastic a maximum of three times; block, two times.
- **Color change** indicates the material is overheated and beginning to scorch: White thermoplastic turns beige or creamy; yellow develops a brown 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.
- Operating tip: Do not completely drain kettle during overnight shutdown unless material must be replaced. Keep kettle closed to protect against moisture and other contaminants.
- Precautions: Guard against temperature loss during transfer.
- Safety tip: Keep a bucket of ice water on site during application. In case of accidental contact with hot thermoplastic, use the ice water to cool affected areas immediately. Follow instructions on Materials Safety Data Sheet or call physician immediately.

Thickness

The specified alkyd or hydrocarbon thermoplastic thickness may vary from 30 to 125 mils. The service life of a thermoplastic marking is directly related to its thickness. A thin line will wear out much faster than a thicker line. To ensure that the proper thickness is being applied, both the wet and the dry line thickness of the line may be routinely checked.

The most accurate determination thickness can be accomplished by laying a metal panel or black duct tape in the dispensing device path. After the application is made on the panel, it is removed and total material thickness and panel can be measured with a micrometer. Subtract the panel thickness measured to calculate the true thickness of the thermoplastic line applied.

The thermoplastic thickness should be uniform and consistent throughout the total length of the job. Overall discrepancies in the application rate and the total thermoplastic thickness will affect the durability and performance of the line.

Appearance

The applied thermoplastic markings should be inspected continually for overall workmanship. Markings should be of the specified width, with clean cut edges. White, yellow, red, black and other colors should appear distinct. The drop-on glass bead application should appear uniform on the entire marking surface. Over saturation with glass beads can cause excessive live embrittlement and premature abrasion. The hardened thermoplastic should resist deformation, dirt pick up, etc. by traffic within 2 to 10 minutes of application.

The marking should be firmly bonded to the pavement surface. If the thermoplastic marking can be easily removed from the pavement with the use of a putty knife, and little or no bituminous substrate is on the back of the marking, then it can be assumed there is not a sufficient bond to the substrate. There must be fusion with the bituminous pavement to ensure maximum mechanical bond strength. Concrete bond strength can be checked by attempting to force separation with a stiff putty knife.

SUCCESSFUL APPLICATION BASICS

Road Surface

- The surface is clean and dry.
- Deteriorated existing markings or curing compound have been removed. (Note: Do not apply thermoplastic over existing tape products.)
- If existing line is well-beaded, the line should be roughed, especially if beads were coated with silicone.
- If premark was dressed with drop-on beads, it should be roughed to promote a good bond with the thermoplastic.
- Portland cement or asphalt that is more than two years old, that is oxidized and/or has exposed aggregate has been primed according to the thermoplastic manufacturer's recommendations.

Temperature

- Surface 50^0 F and rising
- The air and surface temperatures are at least 50^0 F and rising.
- The thermoplastic has heated to at least 400^0 F and no higher than 450^0 F, for no longer than six hours.

Materials/equipment

- Verify material certification (thermoplastic, glass beads, and primer/sealer, where required). Take material samples according to your agency's sample and testing procedures. Check contractor's equipment against contract requirements.

During application, check:

Drop-on bead application

- Beads are adhered to a depth of 50 to 60% of bead circumference.
- Bead application is by machine except where technically impossible.
- Material is properly bonded

Workmanship

- Markings are uniform
- Straightness conforms to specifications.
- Cut-off is clean. There should be no excessive overspray, and any excessive dribble should be removed.