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16. ABSTRACT
This report is a continuation of Interim Report FHWA/CA/TL-83-03 and describes work done to put water-borne traffic paint on an operational basis. Laboratory work and field trials on durable high solids traffic coatings are described including polyester, polyester-epoxy, final evaluations of epoxy coatings, epoxy, alkyd and hydrocarbon thermoplastics, low-temperature thermoplastic, inlaid thermoplastic and lead-free traffic paints. Also included are specifications and test methods that have been developed for thermoplastic and water-borne traffic paints.

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

INVESTIGATE ALTERNATIVES FOR SOLVENT-BORNE TRAFFIC PAINT

Final Report

Study Supervised by .... Mas Hatano, P.E.

Co-Principal Investigator .... Raymond Warness and
Don Chatto

Co-Investigator .... Ben Beede

Report Prepared by .... Don Chatto

RAYMOND A. FORSYTH, P.E.
Chief, Office of Transportation Laboratory

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NOTICE

CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quality	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic years (yd^3)	3.785 .02832 .7646	litre (l) cubic metres (m^3) cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s	28.317	litres per second 1/s)
	gallons per minute (gal/min)	.06309	litres per second (1/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G) (ft/s^2)	9.807	metres per second squared (m/s^2)
Density	(lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) (1000 lbs) kips	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British termal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (in-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi) pounds per square foot (psf)	6895 47.88	pascals (Pa) pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi$\sqrt{in}$)	1.0988	mega pascals$\sqrt{metre}$ (MPa$\sqrt{m}$)
	pounds per square inch square root inch (psi$\sqrt{in}$)	1.0988	kilo pascals$\sqrt{metre}$ (KPa$\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{+F - 32}{1.8} = +C$	degrees celsius (°C)

ACKNOWLEDGEMENTS

The investigators would like to thank the various paint, thermoplastic , and raw material manufacturers for their interest and cooperation during this project.

Special acknowledgement must be given to all of the personnel in the Office of Highway Maintenance who cooperated and provided assistance in this project. Without their support, field application of materials evaluated in this project would not have been possible.

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INTRODUCTION

Solvent-borne traffic paint has been the most common road delineation coating for many years. The paint used for this purpose dries rapidly and normally contains a significant quantity of highly volatile solvents.

In July 1977, the California Air Resources Board proposed a model rule for local air quality control districts that strictly limited the quantity of volatile organic compounds contained in a traffic marking material. The level of volatile organic compounds (VOC) was set at a maximum of 250 grams per liter of paint, minus the water content. The proposed rate was scheduled to become effective September 2, 1982. In most cases, exemptions were granted that extended this date to September 1984.

In August 1982, the South Coast Air Quality Management District (Los Angeles basin) enforced Rule 442, which limits VOC emissions to a maximum of 600 lb/day. This would limit the application of solvent-borne paint to 175 gal/day for each striper. The maximum application of 175 gal/day for a striper capable of applying 500 gal/day would impair operational efficiency and only add to the present backlog of road striping. Fortunately, the development of water-borne traffic paints had progressed to a point where the Los Angeles area could be provided with water-borne traffic paint which met all air pollution regulations.

As a result of these current and impending air quality regulations, it was necessary to investigate all practical alternatives to solvent-borne traffic paint. Materials investigated were water-borne traffic paints and the high solids durable pavement markings consisting of polyester, polyester-epoxy, two-component epoxy, epoxy, alkyd and hydrocarbon thermoplastic and cold preformed plastic traffic stripe.

The initial work on water-borne traffic paints and application of some of the high solids durable pavement markings were reported in Interim Report

FHWA/CA/TL-83/03, Investigate Alternatives for Solvent-Borne Traffic Paint, January 1983. In addition, the interim report concluded that preformed plastic tape is an alternative to solvent-borne traffic paint only where it can be shown to be cost-effective.

This final report describes the steps in the development of performance specifications for water-borne traffic paint, where the formulator is allowed to choose from a wide range of vehicles and pigment loading to meet the performance requirements of the specification and still is free to try the latest improvements in water-borne technology.

In the investigation of durable high solids pavement markings, both laboratory and field work are described in evaluating polyester, polyester-epoxy, two-component epoxy, epoxy, alkyd and hydrocarbon thermoplastic. Since thermoplastics offered the most durable and operationally feasible traffic coating, considerable effort was expended in developing performance specifications and test methods for these materials.

CONCLUSIONS

Rapid Dry Water-Borne Traffic Paints

- Are proven alternatives to solvent-borne paints.
- May be hot or cold applied depending on equipment and weather conditions.
- Provide service life equal to or better than solvent-borne paints.
- Provide bead retention superior to solvent-borne paints.
- Usage is expected to increase in cases where road conditions do not warrant application of thermoplastic.

Polyester Traffic Line Paint

- Provides acceptable service only during summer months in snow areas.
- Presents health and fire hazard concerns over use and storage of the organic peroxide catalyst.
- Has a long no-track time that is unacceptable for mainline striping.

Polyester-Epoxy Traffic Line Paint

- Is unacceptable for use due to extremely poor road performance.
- Presents health and fire hazard concerns over use and storage of the organic peroxide catalyst.

Two-Component Epoxy Traffic Line

- Is unacceptable for use due to inconsistent road performance and poor color stability.

Epoxy Thermoplastic

° Is unacceptable for use due to very poor bead retention, application problems and dirt pickup.

Hydrocarbon Thermoplastic

° Can be used wherever a long-life pavement marking material is required.

° In granular form packaged in meltable plastic bags or in solid block form has demonstrated good shelf life and excellent application properties.

Alkyd Thermoplastic

° In granular form packaged in meltable bags is unacceptable due to poor shelf life and inconsistent application properties.

° In solid block form has shown acceptable application properties and road performance.

Low-Temperature Thermoplastic

° As a coating in the snow areas has shown excellent adhesion and performance as compared to regular thermoplastic, but is not entirely resistant to snowplow activity.

Inlaid Thermoplastic

° Has shown good results during limited tests in snow areas with low-temperature thermoplastic.

° Should continue to be evaluated with different low-temperature thermoplastic materials.

Lead-Free Coatings

° Have shown promising results during laboratory testing of yellow water-borne traffic paint.

° Should continue to be investigated in both traffic paint and possibly yellow thermoplastic.

IMPLEMENTATION

° Rapid dry water-borne traffic paint is now operational in most of Southern California. The 1984 traffic paint contract included an order for 243,000 gallons of water-borne traffic paint.

° New application equipment is being purchased. Specifications require the new paint stripers to be compatible with water-borne traffic paint.

° Hydrocarbon thermoplastic is now operational statewide and its use is anticipated to increase as new application equipment is purchased.

° A contract for 800 tons of hydrocarbon thermoplastic was awarded for 1984-85 for use primarily with the main line striper.

BENEFITS

Thermoplastic Traffic Line Coating

° Contains no volatile carriers, 100% solids.

° Complies with all air pollution regulations.

° Provides a service life of five years or more.

° Provides day and night lane delineation that is superior to traffic paint.

° Material cost on a solids basis is equal to traffic paints.

Water-Borne Traffic Line Paint

°Reduced flammability results in safer application conditions and reduced shipping and handling hazards.

- Complies with all air pollution regulations.
- Has no strong solvent odor and induces few respiratory complaints from users.
- Has improved bead retention as compared to solvent-borne traffic paints.
- Has shown dry times equal to solvent-borne paints.
- Has shown service life equal to or better than solvent-borne paints.

DURABLE HIGH SOLIDS PAVEMENT MARKINGS

A. Polyester Traffic Line Paint

Description and Properties

Polyester traffic paint is a two-component system, consisting of a polyester resin and styrene monomer with lesser amounts of wetting agents, adhesion promoters and usually cobalt naphthenate. Prime color pigments for the white and yellow are titanium dioxide and chrome yellow. The extender pigment is usually calcium carbonate. The addition of 1 to 5% by weight of organic peroxide polymerizes the resin to a solid, thermosetting plastic. The catalyst is a methyl ethyl ketone peroxide (MEKP) solution and is added to the resin side prior to application.

Polyester traffic line coatings manufactured by Glidden, Reichhold and Baltimore Paint were evaluated for physical properties in the laboratory and later with field application. Physical properties of the uncatalyzed paints are shown in Table 1 and the catalyzed paints in Table 2.

The usual MEKP level for reacting polyester is about 1% by weight. Table 2 shows both low and high loadings of MEKP. It appears that excessive catalyst levels should be avoided as evidenced by the very low tensile strength the Reichhold material developed at 5% MEKP as compared to the high tensile strength with 1% MEKP loading. The Glidden material at 5% level was lower than the 1% but not as pronounced as the Reichhold material. It appears that the manufacturers recommended catalyst level should be followed closely.

The ultraviolet (UV) stability of white and yellow polyester traffic line paint is satisfactory. The polyester systems are far more light-stable than the two-component epoxies we have examined.

operator in the cab were not successful as the sulky could not be controlled well enough to produce a straight-line stripe. About 0.1 mile of a yellow two-way turn lane was applied using the sulky. Most of the test areas were applied as pavement markings, using stencils and the hand-held Binks Model 18 catalyst gun.

Application data are shown in Table 5. Considerable trouble was encountered with the Binks 18 catalyst gun and the Ramrod pump. The catalyst, especially in high winds, was obviously not being properly mixed with the Quickstripe, since the applied films showed soft and hard spots or required excessively long periods of time to cure. The Ramrod pump malfunctioned several times and had to be rebuilt. This inconsistent operation finally became so bad that for applications after 10-6-82, the paint was mixed by hand and applied with conventional paint rollers. This method provided very consistent results and produced a fast cure coating with no soft spots. The catalyst content was varied depending on the ambient temperature. At ambient temperatures of 90°F very fast set times were observed with 2% Lupersol. This necessitated a reduction in catalyst to 0.5% to increase the cure time to six minutes. Conversely, at low temperatures (38°F), a 3% Lupersol level produced a 10 minute cure time.

Beads were applied to all applications with a separate hand-held bead gun and a pressurized bead tank. Bead loadings were approximately 10 lb/gal.

Inspections

Within two days after application of the polyester-epoxy traffic line paint all of the arrow legends in the Sacramento area showed 50 to 75% failure due to lack of adhesion to the PCC substrate. Similar failures were also noted in the foothill and mountain test areas where the material was applied with a spray gun and hand mix-roller application. On bare aged AC, three merge arrows out of six failed in the same manner as those on PCC. Subsequent snowstorms in the mountain areas removed any remnants of the yellow Quickstripe crosswalks and legends.

The no-pick-up time (ASTM D711), or more correctly the cure time, for the polyester systems is 25 to 30 minutes in an unbeaded film 15 mils thick at 77°F. With a high bead load of 15 lb/gal, this time would be reduced to about 15 minutes. Even with high bead loading, 15 minutes would present a tracking problem for main line striping which currently does not require the use of traffic cones to protect the freshly painted line.

Reaction with Asphalt Concrete

A sample of Glidden polyester was catalyzed at the 1% level with MEKP, mixed thoroughly in a cup and a 15 mil film poured over the surface of an asphalt concrete (AC) briquette. The AC briquette was about two months old. After hardening, the film could easily be lifted from the surface of the AC, leaving a wet interface where the polyester had dissolved part of the AC. This reaction with AC was not encouraging and would be disastrous if a polyester traffic line were laid over a freshly applied AC blanket. The same procedure was followed on the laboratory parking lot where the AC was very old. After hardening, the polyester film was well bonded to the hard, oxidized AC.

From the results of the above tests it appears that the bond of polyester paint to AC surfaces would depend on the age of the pavement.

Bond to Portland Cement Concrete

The bond of polyester to portland cement concrete (PCC) was also found to be very poor on a dry, clean but otherwise untreated, concrete surface. When the same surface was sandblasted or acid etched, the bond was satisfactory. Unless polyester application includes some kind of pavement pretreatment, its use over PCC would not seem feasible.

Field Applications

Due to the unavailability of equipment to apply polyester main line stripes and the expense involved to convert an existing regular paint striper for polyester application, it was decided to limit the polyester field trials to pavement markings only.

A five gal capacity air-atomized paint striper was fitted with a Binks Ramrod 101-9000 catalyst pump and a hand-held Binks Model 18 catalyst gun with about 20 ft of hose. Beads were post-applied with a separate hand gun operated from a pressurized bead tank. The flow rates of the polyester paints were calibrated against the pot pressure and the flow rate of the catalyst was also calibrated in grams/minute. Hence, at a particular polyester paint flow rate, the catalyst pump could be adjusted to give a 1% level of catalyst. The catalyst was injected externally into the polyester spray. The cost of the conversion was about $1,200.00 and worked satisfactorily.

At the request of the Office of Highway Maintenance, all the field applications were applied in the Lake Tahoe area, at approximately 6000 ft elevation. This area is subject to heavy snowfall in the winter where the action of snowplows, tire chains, sand and salt, as well as freeze-thaw temperatures create extremely severe conditions for any traffic coating.

Polyester traffic paints from Reichhold, Glidden and Baltimore Paint were applied as legends, crosswalks and stop bars. All applications were done at ambient temperature.

In general, application was satisfactory and no-track time surprisingly short considering the cool temperatures, which ranged from 40°F in the morning to about 65°F in the afternoon. At 40°F the no-track time was 40 to 45 minutes and at 60°F decreased to 15 minutes. Initial bead retention was high, with bead loadings of about 20 lb/gal. The bead specification (State Specification 8010-22L-22) is shown in Appendix A.

Night visibility of the applied markings was excellent at all locations. The high bead loading helped significantly in reducing the dirt and discoloration from tire markings when the coating was first exposed to traffic. A small amount of surface tack remains until the coating is fully cured. This surface tack is probably responsible for most of the initial dirt pickup; coatings that were fully cured did not appear to have any additional dirt pickup.

All test installations were placed on old, weathered AC which had remnants of coatings from previous applications. Some areas with excessive oil drippings showed very poor bond with the polyester. Fresh AC or AC contaminated with oil will be further softened by the styrene in the polyester.

On test area on SR89 had excessive surface oil contamination and about 2 sq ft of a painted directional arrow was quickly removed by traffic. The surface oil was removed by washing the area with water and Spic & Span and flushing it with clean water. After the area was dry, it was recoated. The second application then adhered satisfactorily. The junction of SR28 and SR89 in Tahoe City also showed excessive oil contamination. This site was not cleaned as only one edge of the northbound SR89 arrows was affected. This area was closely watched for any bond failures.

Due to gun malfunctions, the 45 legend at 50-ED-49.45 and the westbound half of the crosswalk at US 50 at Kyburz Hotel also had to be recoated. A plugged gun tip and improper catalyst flow caused the coating to be excessively slow to cure and subsequent traffic removed the first application.

Approximately 60 gal of polyester were used for a total legend and crosswalk coverage of 3620 sq ft. This averages to a film thickness application of 27 mils. Spot checks of the paint film, with no beads, gave thickness readings from 18 to 25 mils. During application, no attempt was made to apply a specific thickness, the only criterion was to completely cover the substrate which, in many instances, was very uneven and rough.

The data for the polyester field application are shown in Table 3.

Inspections

The polyester applications were inspected on September 2, 1982, after four months of service life. All test sections were in good condition with no evidence of spalling, chipping or wear. Bead retention and nighttime retroreflection were very good.

On January 11, 1982, after several snowstorms and snowplow, chain and sanding operations, the test areas were inspected. All sections showed almost complete removal of the polyester material, with only remnants remaining.

Summary

Polyester traffic paint has been shown to perform well over aged AC during the short test exposure with legends and crosswalks. Unfortunately, all of our test sites were located in snow areas and a complete evaluation of wear could not be obtained. For pavement marking use, this system would be a viable alternative, but for main line striping we cannot visualize this type of coating ever being applied without traffic cones. The comparatively long no-track time would most certainly require lane closure.

The handling, storage and operational use of the organic peroxide catalyst would require extreme caution and presents a definite fire and health hazard to the paint crews. The styrene used in the polyester as a reactive diluent is also considered dangerous. Depending on the concentration, exposure to styrene vapor irritates the eyes and nasal passages and can have a toxic and anesthetic effect with eye damage. Thus, both the organic peroxide and styrene present hazards and require extreme caution in handling.

Table 3

Polyester Application Data

Date	Vendor Color	Location	Legend	Temperature °F Air	Temperature °F Surface	% RH	No Track Time Minutes
5-10-82	Glidden yellow	US 50-Kyburz PM 48.12 WBL	Slow-School-Xing	56	75	45	15
"	"	" " " PM 47.98 EBL	" " "	"	"	"	"
"	"	" " " PM 48.07	X-walk with Diagonals	"	"	"	"
5-11-82	Glidden yellow	US 50-Meyers-Bug Stn EBL	Slow-School-Xings	47	52	62	40
"	"	" " " Cattlemens NBL	" " "	56	85	35	15
"	"	" " " Apache Ave	X-walk	"	"	"	15
"	"	" " " Santa Fe Ave	X-walk	"	"	"	15
5-12-82	Reichhold white	US 50-Kyburz PM 49.45 WBL	45	56	75	60	15
"	"	" " " PM 49.04 WBL	Ped-Xing	"	"	"	15
"	"	" " " Kyburz Hotel	X-walk	"	"	"	"
"	"	" " " Mtnce Stn EBL	45	"	"	"	"
"	"	" " Strawberry PM 57.73 EBL	45	"	"	"	"
"	"	" " " PM 58.62 WBL	45	"	"	"	"
"	"	" " " PM 57.88 EBL	Ped-Xing	"	"	"	"
"	"	" " " PM 58 WBL	Ped-Xing	"	"	"	"
"	"	" " " Strawberry Lodge	X-walk	"	"	"	"
"	"	" " Strawberry PM 57.68 EBL	45	"	"	"	"
"	"	US 50-SR 89 JN	Stop Bar	"	"	"	"
"	"	" " " Left turn lane	Stop	"	"	"	"
"	"	" " " Right turn lane	Stop	"	"	"	"
"	"	" " SR 89 to US 50 EBL	Right Turn Arrow	"	"	"	"
5-13-82	Reichhold white	SR 89-Meyers @ Pomo St NBL	Stop - Ahead	40	48	65	40
"	"	US 50-Meyers WBL to SR 89	Left Turn Arrow	"	"	"	40
"	"	US 50 " to Navahoe St	Right Turn Arrow	"	"	"	"
"	"	" " " " Hopi St	Left Turn Arrow	50	80	50	20
"	"	" " " " Apache Ave E	Left Turn Arrow	"	"	"	"
"	"	" " " " " "	Right Turn Arrow	56	95	38	15
"	"	" " " " Santa Fe Ave	Left Turn Arrow	"	"	"	"
"	"	" " " to Peddlars Faire	Left Turn Arrow	"	"	"	"
"	"	" " " " Ice Rink	Left Turn Arrow	"	"	"	"
5-17-82	Reichhold white	US 50-Meyers at Mtn Harbor EBL & WBL	Signal Ahead	63	106	37	15
"	"	" " " at Pioneer Trail	Stop Bar	"	"	"	"
"	"	" " " Pioneer Trail EBL	Straight Arrow	"	"	"	"
"	"	" " " " " WBL	Straight Arrow	"	"	"	"
"	"	" " " Pioneer Trail	Left Turn Arrow	"	"	"	"
"	"	" " " " " WBL	Signal Ahead	"	"	"	"
"	"	" " "EBL at Pioneer Trail	Right Turn Arrow	"	"	"	"
"	"	" " " " " " "	Right Turn Arrow	"	"	"	"
5-18-85	Reichhold white	EBL & WBL US 50-Riverton PM 39.39 to 39.18	9 Straight Arrows	56	76	44	15
"	"	" "-Kyburz, Kyburz Hotel	Repaint WBL X-walk	"	"	"	"
"	"	Pioneer Trail to US 50	Stop Bar	67	105	24	10
"	"	Pioneer Trail, NBL to US 50	Signal Ahead	"	"	"	10
5-19-85	Reichhold white	JN SR 28-89 Tahoe City	X-walk	62	98	31	15
"	"	" " " " "	Double Arrow	"	"	"	"
"	"	" " " " "	Left Turn Arrow	"	"	"	"
"	"	" " " " "	2 Straight Arrow	"	"	"	"
"	Glidden white	" " " " "	X-walk	"	"	"	"
"	"	" " " " "	Stop Bar	"	"	"	"
"	"	" " " " "	5 Straight Arrows	"	"	"	"
"	3M Greenlite	SR 89 By Pass	X-walk & Stop Bar	"	"	"	1
5-20-82	Baltimore yellow	SR 89-Sierraville School	2-Slow-School-Xing	54	82	46	15
"	"	" " " "	X-walk	"	"	"	"

B. Polyester-Epoxy Traffic Line Paint

Description and Properties

Polyester-epoxy traffic line paint is a two-component system, consisting of an epoxy-modified polyester catalyzed with 1 to 3% by weight of organic peroxide. This product is very similar to polyester traffic line paint, but has a much faster cure time. This material is marketed by Chagrin Valley Industries, Inc. (CVI), Chagrin Falls, Ohio, under the trade name Quickstripe.

Laboratory evaluation of Quickstripe showed a high viscosity of 104 KU for both the white and yellow coatings. Spray tests through a small air-atomized striper gave very poor spray application with considerable splatter and poor leveling properties. The color of the white was very poor, with a reflectance of 65; the yellow was too red and did not meet Federal 595 highway color standard.

Accordingly, CVI reformulated Quickstripe. Viscosities of the reformulated material, 72 KU for the white and 77 KU for the yellow, improved the spray properties of both colors and spray tests were satisfactory with good leveling properties and no splatter.

Properties of the catalyzed system are shown in Table 4. Lupersol 224 (2, 4 Pentanedione Peroxide) was used in place of MEKP at the manufacturers recommendation due to a higher flash point of 214°F as compared to 137°F for the MEKP. The organic peroxide Lupersol 224 is also classified as corrosive and a severe eye irritant.

Table 4

Properties of Quickstripe Catalyzed with 1% Lupersol 224

Color	Wet Film Thickness Mil	ASTM D711 No-Pick-Up Minutes	Tensile PSI	Elongation %	ASTM D2240 Durometer Hardness D	ASTM E97 Daylight Luminous Reflectance	ASTM E313 Yellowness Index
White	15	30					
	125	6	5925	2	80	82.5	8
Yellow	15	30					
	125	6	5675	2	80	58.5	

Reaction With AC

Quickstripe catalyzed with 1% level of Lupersol 224 was applied to an AC briquette, allowed to harden and observed. It was found to behave in the same manner as regular polyester paint, softening the asphalt and leaving a wet interface. The hardened film could easily be lifted from the surface of the AC.

Bond to PCC

Two PCC test blocks 12 in. x 12 in. x 3 in. thick were wire-brushed. Quickstripe white and yellow paints with 2% Lupersol were applied to each block at film thicknesses from 25 to 100 mils. Less than one hour after application, both white and yellow films curled up and completely lost adhesion to the substrate. The curling was more pronounced in the thicker areas of the film. In places on the test block where no curling was observed, there was absolutely no bond to the PCC. The coatings were then completely removed and the blocks thoroughly sandblasted. Coatings were applied and observed as before. This time there was no curling. However, the cured coatings exhibited some buckling but the film did not break. A spatula inserted under one edge of the film removed the whole film with little effort. It appears that the poor adhesion is due primarily to excessive cure shrinkage of the film.

First Field Application

The hand-pushed sulky on our air-atomized paint striper was rigged with a Binks Model 460 catalyst gun just ahead of a Binks Model 61M paint gun. The Model 460 gun was connected to the Binks Ramrod 101-9000 catalyst pump and the Quickstripe was fed from a 5 gal paint pot to the 61M gun. A modified Binks 21 paint gun was used to post-apply glass beads from the pressurized pot. We anticipated using this operation to apply main line stripes but decided that the operation was unsafe since the sulky operator would be on foot. Attempts to mount the sulky on the front of a pickup truck with the operator in the cab were not successful as the sulky could not be controlled well enough to produce a straight-line stripe. About 0.1 mile of a yellow two-way turn lane was applied using the sulky. Most of the test areas were applied as pavement markings, using stencils and the hand-held Binks Model 18 catalyst gun.

Application data are shown in Table 5. Considerable trouble was encountered with the Binks 18 catalyst gun and the Ramrod pump. The catalyst, especially in high winds, was obviously not being properly mixed with the Quickstripe, since the applied films showed soft and hard spots or required excessively long periods of time to cure. The Ramrod pump malfunctioned several times and had to be rebuilt. This inconsistent operation finally became so bad that for applications after 10-6-82, the paint was mixed by hand and applied with conventional paint rollers. This method provided very consistent results and produced a fast cure coating with no soft spots. The catalyst content was varied depending on the ambient temperature. At ambient temperatures of 90°F very fast set times were observed with 2% Lupersol. This necessitated a reduction in catalyst to 0.5% to increase the cure time to six minutes. Conversely, at low temperatures (38°F), a 3% Lupersol level produced a 10 minute cure time.

Beads were applied to all applications with a separate hand-held bead gun and a pressurized bead tank. Bead loadings were approximately 10 lb/gal.

Inspections

Within two days after application of the polyester-epoxy traffic line paint all of the arrow legends in the Sacramento area showed 50 to 75% failure due to lack of adhesion to the PCC substrate. Similar failures were also noted in the foothill and mountain test areas where the material was applied with a spray gun and hand mix-roller application. On bare aged AC, three merge arrows out of six failed in the same manner as those on PCC. Subsequent snowstorms in the mountain areas removed any remnants of the yellow Quickstripe crosswalks and legends.

Table 5

Quickstripe Application Data

DATE	COLOR	LOCATION	TYPE	TEMPERATURE °F		NO TRACK MINUTES	TYPE OF ALLICATION
				AIR	SURFACE		
9-21-82	Yellow	SR28 Tahoe City Woolco Stn to Grove 0.1 mile AC	2-way turn lane-solid & dash	71	92	5	Sulky operated spray gun with 2% Lupersol 224
9-22-82	Yellow	SR49 Loyalton at W.Fourth St. AC	X-walk	59	88	5	" " "
9-23-82	Yellow	SR49 Loyalton at 2nd	X-walk	75	95	5	" " "
	"	" " " 4th	X-walk	"	"	"	" " "
	"	" Loyalton Pharmacy	X-walk	"	"	"	" " "
	"	" Loyalton, north-bound	Sig. ahead (2)	"	"	"	" " "
	"	" " Willow	Slow-school X-ing	"	"	"	" " "
	"	" " 3rd	Slow-school X-ing	"	"	"	" " "
		All on AC					
10-5-82	White	I-5 Northbound at 880 Jn. from 5 SAC 26/80 - 27/00 on bare PCC	Merge arrows(6)	70	85	1 hour + due to poor catalyst mixing in spray gun. 1st arrow at 5-SAC 26/80 coated with 3M Greenlite then recoated with Quickstripe.	
10-6-82	White	I-80 westbound at Industrial Ave. 80 YO 9/21 Lane 4	1st merge arrow is 3M Greenlite,	63 High	80 Winds		
			Next 2 are Quickset	"	"	2 hours + due to poor catalyst mixing in spray gun	
10-7-82	White	US 50 eastbound 50 SAC 1/00 on bare PCC NR 59 off.	3 merge arrows	59	80	Hand mixed & roller applied in 1/2 gal batches at 2% Lupersol 6 min. no track - No soft spots.	
		US 50 westbound at 50 SAC 9/00 NR Mather O/C on bare AC	3 merge arrows	73	110	3	Hand Mixed & roller applied 1% Lupersol
10-8-82	White	I-80 eastbound 80 Pla 52/48-52/64 Blue Canyon on bare PCC	6 merge arrows	54	73	6	Hand Mixed & roller applied 2% Lupersol
10-13-82	White	I-80 eastbound 80 Pla 27/00 Heather Glen on bare AC	1st 3 arrows are Quickset next 4 arrows are 3M Green-lite	77	113	6	Hand Mixed & roller applied 0.5% Lupersol
10-14-82	White	SR 28 north of Tahoe City of Old County Road	Stop bar (Old County Road)	38	40	10	Hand Mixed & roller applied 3% Lupersol
		Chinquapin & Old County Road new AC (bare) about 1 month old	Left turn arrows (4)	"	"	"	"

The 3M Greenlite flame spray markings applied as controls remained intact with no sign of adhesion loss. The control lines were eventually worn away during the rest of the winter.

Summary

The initial ioterest in Quickstripe centered around its fast cure time as compared to regular polyester traffic paints. This would have enabled application of main line stripes without cones or traffic control. However, the complete lack of adhesion to PCC and the poor bond to AC offsets any fast cure proqerties. We recommended that no further work should be done with this coating. However, CVI insisted on gurther trials and were told any further work would have to be totally at their expense. CVI agreed and provided a contractor, equipment, material and labor for the second field application.

Second Field Application

This test was!applied by a contractor under the supervision of two CVI employees. Pavement markings and legends only were applied using a hand-held catalyst gun with an internal catalyst mix. Lupersol 224 was used as the catalyst. Application was restricted to the Sacramento and Stockton areas on AC and PCC. Application data are shown in Table 6. Application thickness averaged 20 mils.

Inspections

The Stockton area locations were inspected December 12, 1983. The crosswalk marking applied over chip seal at SR88 and Baker Road showed wear in the wheel track, however, the yellow traffic paint control showed very little wear. At SR4 and Farmington Road, large portions of the yellow Quickstripe were missing. The yellow traffic paint control was in good condition.

Table 6

Quickstripe 2nd Application Data

DATE	COLOR	LOCATION	TYPE	TEMPERATURE F°		NO TRACK TIME
				AIR	SURFACE	TIME - MINUTES
7-31-83	White	US 50 SAC 1.00 eastbound on PCC	3 lane Drop Arrows	74	100	5
8-31-83	White	I-5 at Jn. I-880 northbound on PCC	3 lane Drop Arrows +3 Stamark Arrows	83	118	4
9-1-83	Yellow	SR4, Charter Way westbound at Commerce Stockton on AC	X-walk and Slow-School-Xing	75	100	11
9-1-83	Yellow	SR4 at Farmington Road AC Stockton	X-walk - 1/2 with Yellow Traffic Paint Control	83	118	11
9-1-83	Yellow	SR88 at Baker Road eastbound - Stockton Chip Seal AC	X-walk 1/2 with Yellow Traffic Paint Control	83	114	8

On SR4 at Commerce St., the Quickstripe was in very poor condition with adhesion loss from 40 to 100%. The yellow traffic paint control showed some wear but was in satisfactory condition.

On January 19, 1984, the Sacramento test sites were inspected. All lane drop arrows were considered failures, with adhesion losses from 30 to 90%. The 3M Stamark cold preformed arrows installed as a control were all in excellent condition.

Summary

After two field trials, both showing complete failures in adhesion to both AC and PCC, the Quickstripe polyester-epoxy system does not warrant further evaluation.

C. Final Inspections of Prismo Epoxy System

Prior History

Contract application of the Prismo two-component epoxy traffic line was described in Interim Report FHWA/CA/TL-83/03. This material was applied during June 1981 in Southern California and showed considerable discoloration and dirt pickup 24 hours after application in the desert areas in Holtville and Calexico. The I-5 installation at Gorman, elevation 4000 ft, failed completely in adhesion after four months service from June to September 1981.

A four-month inspection of the I-10 section in Santa Monica and I-8 in Descanso showed some yellowing of the white stripes, but adhesion and bead retention were satisfactory.

Final Inspection After 1 3/4 Years Service

I-10 Santa Monica

The white stripes had a pronounced yellow color with considerable spalling and loss of material due to poor adhesion.

I-8 Descanso

The white stripes had a pronounced yellow color. Wear, adhesion of material and bead retention were satisfactory.

SR115 - Holtville

All legends, crosswalk and main line stripes were in very poor condition. The white color was extremely dirty and the yellow had weathered to a deep orange color. The material had considerable loss of adhesion in all areas, however, beads were still visible in sections that were intact.

SR98 and SR111 Calexico

None of the painted legends and crosswalks in the downtown area were visible in the daylight due to extreme dirt pickup. There was considerable material loss due to poor adhesion. The yellow median lines were no longer yellow but had changed to a deep orange color. The material also showed very poor adhesion, however, beads were still visible in scattered areas.

SR111 and Junction SR98 to 111 Imp 8.00

Dirt pickup on the painted line in this area was not as pronounced as in the downtown sections, but the white lines showed a definite yellowing and loss of adhesion. Bead retention was satisfactory.

The Holtville and Calexico areas were inspected with the assistance of district personnel and were judged to be no longer serviceable.

D. Epoxy Thermoplastic

Prior History

Initial work with epoxy thermoplastic was described in Interim Report FHWA/CA/TL-83/03. The initial field trials used a Prismo air-atomized applicator and material made by Bonded Products of West Chester, Pennsylvania. The interim report terminated with a 6-month inspection of the test areas.

Inspection After 2 1/2 Years

Test Section No. 1 - SR17 - Nimitz Freeway
1st Mile Southbound - Hydrocarbon Thermoplastic - Spray Applied

Some edge feathering of the line was observed, this was probably due to splatter during application, otherwise the line was satisfactory. Bead retention was good and nighttime visibility was very good.

2nd Mile Southbound - Raised Marker Section

Daytime delineation with the markers was satisfactory. Some ceramic markers were missing, but no nighttime retroreflective markers were missing. Nighttime retroreflection was very good.

3rd Mile Southbound - Hydrocarbon Thermoplastic - Screed Applied

The line was in excellent condition with sharp edges and no feathering. Daytime color and delineation were very good. Nighttime visibility was excellent.

4th Mile Southbound - 3M Stamark Tape

The tape was intact with no loss. The daytime delineation was satisfactory, however, nighttime delineation was very poor due to high bead loss.

1st Mile Northbound - Epoxy Thermoplastic - Spray Applied

This section was in very poor shape, with the lines showing advanced stages of alligator cracks and a definite yellowing of the white lines. The beads were completely gone resulting in no nighttime delineation. No significant loss of adhesion was observed but because there was a complete loss of beads and yellowing, this section is considered to be no longer serviceable.

2nd Mile Northbound - Raised Marker Section

This section was in good condition, with satisfactory day and night visibility.

Test Section No. 2 - SR4 - Concord Epoxy Thermoplastic - Spray Applied

Both eastbound and westbound sections showed very poor night visibility. A daytime inspection showed excessive wear of the lines. The alligator or checkered pattern due to cracking and weathering is similar to that observed at other sections. The white line also showed a yellow tinge.

Mini Mac 1000 Applications

Description

The Mini Mac 1000 is a medium-sized, self-propelled riding-type applicator. The material tank is oil jacketed, with a 1000 lb capacity, and is equipped with an air-operated agitator. The hot thermoplastic is pressure fed through stainless steel flex lines to the application guns. All thermoplastic feed lines are heated with circulating hot oil lines. Two 4-in. airless ribbon guns are mounted on the left side of the applicator and one air-atomized gun on the right side. The guns are interchangeable, and an adjustable ribbon gun is available for mounting on either side. This ribbon gun is quickly adjustable to provide line widths from 4 in. to 12 in. The airless ribbon guns provide a constant line width and thickness with sharp, clean edges. The ribbon guns are mounted 2 to 3 in. above the road surface and can be vertically and horizontally adjusted. The ribbon guns are heated by a jacketed hot oil circulating system. The applicator unit has dual hydraulic steering and may be operated with two-wheel steering for long line application or four-wheel steering for close turns in legend applications. Power for the applicator is provided by an air-cooled four-cycle propane engine with two propane tanks mounted on the rear of the vehicle.

Spray Gun Application

The epoxy thermoplastic for Mini Mac application was purchased from Pavemark Corp., Atlanta, Georgia. The purchase price for 5 tons of white was $2,433.00/ton and 7 tons of yellow was $2,785.00/ton. This material was rather expensive when compared to hydrocarbon thermoplastic which was purchased at $700.00/ton.

In order to apply epoxy thermoplastic at the recommended thickness of 20 mils, the air-atomized spray gun was tried first. This produced erratic operation, splatter and inconsistent film thickness. To correct this, a modified air-atomized constant bleed gun was purchased along with an auxiliary propane heater to heat the atomizing air supplied to the gun. With the atomizing air at 400°F, 35 psi pot pressure and the material at 430 to 450°F, the application was still unsatisfactory with considerable splatter and intermittent thermoplastic flow at the gun. A propane torch had to be used at regular intervals to keep the thermoplastic flowing.

Epoxy thermoplastic application was found to be best when the pot pressure was maintained at 50 psi. However, this pressure drained most of the available air and left only 30 psi for the atomizing air supply. Under these conditions there was still splatter but the increased pot pressure kept the material flowing and did give better operation for a longer period of time. However, when the gun was shut off for five minutes, it had to be heated with the propane torch to start material flowing again. Average film thickness under these conditions was 25 mils. Attempts to apply the yellow material with the spray gun and heated air were even more unsatisfactory due to constant gun plugging and excessive splatter.

Ribbon Gun Application

Regular ribbon gun applications with hydrocarbon thermoplastic produce line thicknesses of about 90 mils with a pot pressure of 30 psi and a melt temperature of 425 to 450°F. It was reasoned that a thinner film thickness could be attained by decreasing the plastic flow with lowered pot pressure and decreased temperature. This was tried with the epoxy thermoplastic and was an immediate success. With a pot pressure of 10 psi and the material at 400°F, line thickness was 36 mils. No splatter occurred and lines had sharp, clean edges. Although application under these conditions produced very satisfactory stripes, there were some problems in material flow at this temperature.

The best operation with the ribbon guns was at a material temperature of 450°F and 10 psi pot pressure. Under these conditions line thickness averaged 50 mils but operation was excellent. Initial post-applied glass bead retention was satisfactory. Initial nighttime retroreflection was also satisfactory. The remainder of the 12 tons of epoxy thermoplastic was applied in the Oakland and Marysville areas. Application data are shown in Tables 7 and 8.

Table 7

Epoxy Thermoplastic Application Data
District 4

Date	Color	Gun Type	Location	Type Line	Temperature °F Air	Temperature °F Surface	Temperature °F Material	POT PSI	Atomizing Air PSI	Line Thickness Mils	Notes
8-26-83	White	Spray	SR 238, Maury to Driscol, north & south, AC	Edge	85	120	430	30	35	40	Splatter, plugging.
	"			"	85	120	450	50	30	35	Improved but still splatters.
8-29-83	White	Spray	"	"	84	120	445	50	30	30	Splatter.
8-30-83	Yellow	Spray	Mill Valley, IMRN 0.00-0.50 AC	Center	75	80	430	30	30		Plugging & splatter -stop-
		Ribbon	IMRN 0.00-4.65 AC	"	75	80	450	12	-	60	Good operation. No splatter.
9-1-83	Yellow	Ribbon	Livermore, SR 084 ALA 29.53 to Scott Street AC	Solid and Dash	85	100	445	12	-	50	" "
9-6-83	Yellow	Ribbon	Mill Valley, IMRN 4.65-6.10	Dash	70	85	440	12	-	50	Operation OK
			IMRN 6.10-7.84	Dash	70	85	450	12	-	50	" "
9-7-83	Yellow	Ribbon	IMRN 7.84-11.70	Dash	64	66	400	20	-	40	" "
			IMRN 11.70-12.37 AC	Dash and Solid	64	66	438	15	-	60	" "

Table 8

Epoxy Thermoplastic Application Data Ribbon Gun
District 3

Date	Color	Location	Line Type	Temperature °F Air	Surface	Material	Pot psi	Line Thickness mils	Sample Location
9-14-83	Yellow	Jn SR99 & SR70	Solid	103	130	400	10	42	
		Southbound	Double-	"	"	"	"	40	
		2.5 miles	Dash	"	"	"	"	45	
		AC							
9-15-83	Yellow	SR99 Southbound	Solid	76	82	413	10	38	99 Sut 5.00
		5.5 miles	Double-	"	"	"	"	36	99 Sut 4.00
		AC	Dash	"	"	400	12	23	99 Sut 0.00
9-16-83	Yellow	SR99 Southbound	Solid	77	85	400	10	28	99 Sac 35.00
		2.0 Miles	Double-	"	"	"	15	40	99 Sac 33.00
		AC	Dash						
9-20-83	Yellow	SR 65 Southbound	Solid	85	96	450	15	70	65 Yub 3.00
		65 Yub 3.70 to	Double-	"	"	"	"	60	65 Yub 1.97
		65 Pla 23.90	Dash	"	"	"	"	70	65 Pla R 24.26
		4 miles		"	"	440	15	55	65 Pla 23.19
		AC		"	"	"	"	60	65 Pla 22.20
9-21-83	Yellow	SR65 Southbound	Solid	86	97	450	15	60	65 Pla 19.00
		65 Pla 3.70 to	Double-	"	"	"	"	60	65 Pla 15.00
		65 Pla 14.31	Dash						
		3.5 miles							
		AC							
9-23-84	Yellow	SR65 Southbound	Solid	65	66	450	15	60	65 Pla 14.22
		65 Pla 14.31 to	Double-					80	65 Pla 13.33
		65 Pla 9.19	Dash	76	85	450		60	65 Pla R 11.66
		4.4 miles							
		AC							
9-27-83	White	I-5 & SR99	Edge	72	75	420	15	55	
		Northbound							
		1.1 miles							
		AC							
10-3-83	White	SR99 Southbound	Edge	81	85	450	15	50	99 Sut 0.00
		99 Sut 1.53 to							
		99 Sut 0.00							
		1.8 miles							
		AC							
10-4-83	White	99 Sut South-	Edge	75	85	430	15	65	
		bound to I-5	"	"	"	420	10	30	Elverta Road
		AC	"	"	"	430	15	50	

Inspections of Epoxy Thermoplastic Test Areas

Oakland Area - After 6 Months

On SR1 from Mill Valley to Stinson Beach. This area is a narrow two-lane asphalt concrete road with many sharp curves and grades along the coastline north of San Francisco. Along the first four miles, which carries most of the local Mill Valley traffic, the lines were almost completely obliterated by black tire and skid marks. Wear and adhesion were satisfactory and color was good where the lines were not covered with black tire marks. The nighttime visibility was very poor especially in the high traffic area where beads were almost nonexistent. On the straight sections, away from the local traffic, beads were visible, but provided only fair nighttime delineation.

On SR84, Livermore, the double yellow and dash lines showed good adhesion, color and durability, but again bead retention was very poor.

Marysville Area - After 6 Months

On SR65, the yellow dash and double yellow centerline showed good adhesion, color and wear. Nighttime retroreflection was fair to poor. SR99 also showed good adhesion, color and durability on the yellow centerline but again bead retention was very poor and resulted in unsatisfactory nighttime visibility.

Summary

The epoxy thermoplastic appeared to have two main problems: the inability to retain glass beads and application problems especially with air atomized spray guns. The glass bead application system on the Mini Mac 1000 is excellent, the best we have seen on any thermoplastic striper, so we cannot fault the apparatus.

Air-atomized spray gun application of the epoxy thermoplastic was inconsistent and was characterized primarily by excessive splatter and generally poor operation. As shown in our field trials, the only reliable application was with the airless ribbon guns. Lowering the melt temperature and decreasing the pot pressure did yield film thicknesses of 20+ mils, but, while ribbon gun operation was vastly improved over the spray guns, flow to the guns was not consistent and resulted in frequent gun stoppage. When applying this material, the best operation of the ribbon guns was at 450°F. This, of course, increased material flow amd led to much higher film thickness, but very good operation.

Formula Revision

The original formula for epoxy thermoplastic had a binder content of 59.5% and a glass bead content of 16.7%. Most hydrocarbon thermoplastics in use today have binder contents from 20-25% by weight and glass bead levels of 25-30%. The bead level of the epoxy thermoplastic could be raised to a minimum of 25%. It is not understood why the binder content is so high. If the binder content were lowered, the cost of this material could be decreased and, perhaps, application properties would improve. The original 60/40 formula is shown in Table 9 and a suggested revision is shown in Table 10.

The revised formula has an increased bead content, and a reduced binder content which results in a 38.6% reduction in raw material cost. The advantage of the low density in the original formula is lost. The revised formula has a density similar to that of regular hydrocarbon thermoplastic. The viscosity of the revised formula would certainly be much higher than the original, but the airless ribbon guns have shown the capability of applying hot melt thermoplastic having viscosities as high as 200 to 300 poises at 425°F. A lower binder content should also reduce the yellowing tendency of the white material.

Table 9

Original 60/40 Formula

	Lb	Gal	Lb/100 Gal	% Wt	$ Unit/Lb	Total	RMC $/Lb
Epon 1007F	30	3.12	455.24	59.52	1.116	$ 528.08	
Epon 828	20	2.07	303.49			352.05	
TiO_2	10	0.29	151.75	11.91	0.75	113.81	
$CaCO_3$	10	0.44	151.75	11.91	0.05	7.59	
Beads	14	0.67	212.44	16.67	0.25	53.11	
	84	6.59	1274.67	100.00		$1054.64	$0.83

Table 10

Revised Formula

Epon 1007F	15	1.56	292.40	29.77		$ 339.18	
Epon 828	10	1.04	194.93			226.12	
TiO_2	10	0.29	194.93	11.91		146.20	
$CaCO_3$	28	1.24	545.81	33.33		27.29	
Beads	21	1.00	409.36	25.00		102.34	
	84	5.13	1637.43	100.00		$ 841.13	$0.51

E. Alkyd and Hydrocarbon Thermoplastic

Background

The first extensive hydrocarbon thermoplastic study was undertaken in late 1975 and early 1976. This work was reported in Interim Report FHWA/CA/TL-83/03, "Investigate Alternatives for Solvent-Borne Traffic Paint." The original application was covered in Report CA-DOT-TR-1134, "Optimization of Traffic Lane Delineation Systems." Performance of the hydrocarbon test sites in this study was carefully monitored for five years by both district maintenance and laboratory personnel. Some sections of this study are still serviceable after eight years of exposure.

Information gained from this study and the successful performance of the hydrocarbon thermoplastic was largely responsible for the decision to use the hydrocarbon thermoplastic on an operational basis. This necessitated the purchase of new application equipment, including a main line striper and premelt support trucks, along with newer and improved small application units for gore striping, crosswalks and legends.

The Marcato Mini Mac 1000 was purchased by the Transportation Laboratory primarily for thermoplastic test work. This unit was the first thermoplastic applicator actually purchased by Caltrans that was capable of applying main line stripes as well as legends and pavement markings. In addition to test work, it was also used as the primary thermoplastic striping unit for Caltrans until the delivery of the Marcato main line striper.

Alkyd Thermoplastic

Alkyd thermoplastic was initially promoted by Pavemark Corp. as an improvement over the hydrocarbon type. The alkyd type consists of a maleic modified glycerol ester of wood rosin and is reported to be incompatible with oils and grease, whereas the hydrocarbon formulations usually react with them resulting in softening and darkening of the thermoplastic. The manufacturer also claims that the alkyd type is more durable than hydrocarbon.

Long Beach Freeway Test Section

The Long Beach Freeway, State Route 7 in Los Angeles County was chosen for a thermoplastic test site. This route runs for 20 miles in each direction on portland cement concrete and carries an Average Daily Traffic (ADT) of 100,000 to 173,000 vehicles. This test section was set up with the following objectives:

1. Determine the most effective method of surface preparation including mechanical wire brushing, detergent washing and priming.

2. Compare the hydrocarbon and alkyd types under high ADT conditions. This includes application, service life, bead retention and color.

3. Estimate actual production rates of application and material usage.

All raised markers delineating both northbound and southbound slow traffic lanes were removed before the thermoplastic application. The original plan was to prepare the surface for 7 miles with no precleaning, other than sweeping away debris caused by the plow removal of the markers; another 7 1/2 miles were to be cleaned with dry mechanical wire brushing and another 5 miles with detergent wash using a mechanized brush washer. This procedure was planned for both northbound and southbound lanes. However, the detergent wash machine broke down after 1/2 mile of washing in the southbound lane and its use was eliminated from the test.

A two-component epoxy primer, Cataphote 922-CTP-11, was applied to all sections except the control nonprimed areas as noted in Tables 11 and 12. The primer was applied with a Binks 21 air-atomized gun, placed just ahead of the Mini Mac 1000 ribbon guns and was applied concurrently with the thermoplastic. The primer was applied at approximately 1 mil wet thickness. The primer was mixed in a 1:1 proportion and had a pot life of 8+ hours. Unused primer was flushed from the pot and lines with solvent after each

Locations on the southbound lane are identified by miles, starting from Valley Boulevard as Mile 0.0 and ending at SR1, Pacific Coast Highway as Mile 20.0. The northbound lane starts at SR1 as Mile 0.0 and ends at Valley Boulevard as Mile 20.0. Application data for the hydrocarbon thermoplastic are shown in Table 11 and the alkyd in Table 12. Surface preparation sections are shown in Table 13.

Table 11

Application Data Southbound-Hydrocarbon

Thermoplastic - Cataphote White, Granular, Meltable Plastic Bags.
Identification - 921 WGA 101E03 000 226-1 201
Plus 900 lb 921-WGA-002E 21602 0000011
in paper bags, used 10-24-82.

Date	Temperature °F Plastic	Temperature °F Air	Pounds Plastic	Pounds Beads	Miles 12/48 Dash	Miles Solid 4-in.	Lb Plastic/ Sq Ft	Line Samples Mile Location	Line Samples Thickness Mils	Unprimed Section
10-17-82	425	75	2150	250	2.0	1.2	0.73	13.2	100	Mile 12.3-14.3
-18-	430	71	975	150	2.0	0.2	0.80	0.2	100	None
-19-	425	75	1000	100	2.2	-	1.00	2.3	110	Mile 3.7-4.3
-20-	445	80	1525	200	4.1	-	0.85	9.0	65	None
								8.8	80	
								8.3	60	
-21-	440	80	975	100	2.8	-	0.80	10.4	80	None
								11.0	80	
-22-	437	85	1000	100	2.2	0.1	0.88	16.5	100	Mile 16.6-17.6
-23-			1000	100	1.0	Not observed.				
-24-			900	100	2.8	Not observed.				
Totals			9525	1100	19.1	1.5				

Sq ft of 12/48 Dash Line = 8320
Sq ft of Solid 4 in. = 2614
Total 10934

Total lb plastic/sq ft = 0.87
lb beads/sq ft = 0.10

Table 12

Application Data Northbound-Alkyd

Thermoplastic - Pavemark, White, Block Form
Identification - W5E 3BX ZB6182, 10-25-82 to 10-28-82
W6C 3BX CC ZB091882, 10-29-82 to 11-3-82

Date	Temperature °F		Pounds		Miles 12/48	Miles Solid	Lb Plastic/	Line Samples		Unprimed
	Plastic	Air	Plastic	Beads	Dash	4-in.	Sq Ft	Mile Location	Thickness Mils	Section
10-25-82			1800	150	3.3	No observed.				Mile 6.9-10.2
-27-	440	74	1475	150	3.8	-	0.89	10.5	100	None
								12.3	100	
-28-	440	80	1400	150	2.9		1.11	1.7	110	Mile 1.4-2.4
-29-	437	78	1100	100	1.4	0.3	0.97	4.0	90	None
-31-	425	72	1065	100	2.1	0.1	0.98	6.0	90	None
11-01-82	427	76	1525	150	3.0	0.2	0.92	16.1	80	None
	390*									
-02-	416	80	1080	100	1.9	0.1	1.10	18.2	100	Mile 17.0-18.0
								18.6	100	
-03-	420	85	800	50	1.0	0.15	1.00	19.6	85	None
								19.8	80	
Totals			10245	950	19.4	0.85				

*From Mile 17.0 to 18.1 Plastic Temp = 390°F
" " 18.1 to 20.0 " " = 416°F

Plastic applied over old polyester & ceramics Mile 17.6 to 18.5.
Sq ft 12/48 Dash = 8451
Sq ft Solid 4-in. = 1481 Total lb plastic/sq ft = 1.00
Total = 9932 " " beads/sq ft = 0.10

Table 13

Surface Preparation

Plastic Type	Direction	No Precleaning	Wire Brush	Detergent Wash
Hydrocarbon	Southbound	Mile 0.0-7.0 Mile 15.0-17.0	Mile 7.0-14.5 Mile 17.0-20.0	Mile 14.5-15.0
Alkyd	Northbound	Mile 0.0-7.0	Mile 7.0-20.0	

No precleaning refers to sweeping up loose dirt and debris from the marker removal operation.

Wire brush used was a mechanical power rotating type. On the detergent wash section, it was necessary to wait until the surface had dried.

Material Costs - Hydrocarbon

9525 lb plastic at $0.433/lb	=	$4,124.33
1100 lb beads at $0.20/lb	=	220.00
*Propane at $37.00/ton plastic	=	176.12
Epoxy primer, 5.8 gal at $15.50/gal	=	89.90
Total	=	$4,610.35
Total sq ft plastic applied	=	10,934
Material cost/sq ft	=	$0.42
Material cost/lin ft (4-in.-wide)	=	$0.14

*Includes propane use for preheater and Mini Mac 1000 heater and propane engine.

Bids for 1985 have shown hydrocarbon substantially lower at $0.313 lb. This would calculate to a material cost of $0.32/sq ft and $0.11 per lin ft.

Material Costs - Alkyd

10245 lb plastic at $0.365/lb	=	$3,739.43
950 lb beads at $0.20/lb	=	190.00
*Propane at $37.00/ton plastic	=	189.53
Epoxy primer, 4.7 gal at $15.50/gal	=	72.85
Total	=	$4,191.81
Total sq ft plastic applied	=	9932
Material cost/sq ft	=	$0.42
Material cost/lin ft (4-inch-wide)	=	$0.14

*Includes propane use for preheater and Mini Mac 1000 heater and engine.

The last bid price on alkyd in 1984 was $0.354/lb. This would calculate to $0.41/sq ft and $0.14 per lin ft.

Application Summary

The application of nearly 10 tons of thermoplastic over a period of 16 days would appear to be a very poor production rate for thermoplastic application. However, this was a multioperation effort in which not only thermoplastic was applied but many other maintenance projects were carried on concurrently. This operation involved closing two lanes of a high ADT freeway and associated ramps for 1 or 2 mile stretches at a time. These closures allowed work to be done by bridge maintenance, electrical maintenance, landscape crews and highway maintenance as well as the application of thermoplastic.

The actual thermoplastic application was satisfactory with no problems. The average speed of the Mini Mac 1000 was 4 mph applying an average film thickness of 85 mils. When the speed was increased to produce a thinner film thickness of 60 mils, the thermoplastic ribbon was broken, producing holes and uneven coverage in the applied stripe. The best operation with the ribbon guns was at a thickness of 85 mils.

The measured flow rate of the alkyd thermoplastic from the ribbon gun at 30 psi pot pressure and a material temperature of 416°F was 100 lb/min. Flow rate of the glass beads was 9.5 lb/min. The average load of thermoplastic for the Mini Mac was 1000 lb. At a flow rate of 100 lb/min this would take 10 minutes to apply. Refill of the applicator takes about 15 minutes for each load. Assuming that material in the premelter is at the proper temperature, then about two loads per hour could be applied. In 8 hours this would amount to about 8 tons of thermoplastic. With only one premelter, this production rate was not possible but with sufficient premelter capacity, the Mini Mac should be capable of applying 8 tons/day in a 10-hour day, which most of the thermoplastic crews work. This figure, of course, would apply to solid line, when dash line is applied on a 12/48 cycle, four times the distance would be covered consuming more time for each load.

Material Cost Comparison Thermoplastic and Traffic Paint

Traffic paint is normally applied at 107 sq ft/gal or a wet film thickness of 15 mils along with 6 lb glass beads/gallon paint. On drying, this produces a dry paint film 8 mils thick.

Cost per 107 sq ft = $4.35 (1984-85 bid price rapid dry solvent-borne)
Beads 6 x .20 = 1.20
Total = $5.55
Cost per sq ft = $0.052 or $0.017 per lin ft

Cost per sq ft hydrocarbon applied 85 mils thick is $0.32 or $0.11 per lin ft.

If traffic paint were applied to yield a dry film thickness of 85 mils then cost per sq ft would be $0.55 or $0.18 per lin ft.

Therefore, traffic paint would actually cost more for an 85 mil thickness.

If we look at material costs on a solids basis only, traffic paint would be calculated as follows:

Cost per gal = $4.35
Wt per gal = 11.50 lb
% Solids = 70%
1 gal contains 8.05 lb solids
Cost per lb of solids = $0.54
The cost per lb of solids for hydrocarbon thermoplastic is $0.31/lb

Traffic paint normally has a service life of one year, hence the cost/year of service life would be $0.052 sq ft. If we consider hydrocarbon thermoplastic at $0.32/sq ft with a service life of 5 years, then the cost per year of service life would be $0.06/sq ft. A service life of 8 years or more is not uncommon for thermoplastic. A 6-year service life for thermoplastic would result in a cost of $0.05/sq ft per year of service life.

In general, an 85 mil application of thermoplastic may sound excessive and expensive but, in reality, it is more economical and provides better delineation over a longer period of time than traffic paint.

Inspection of Long Beach Freeway

After 5 Months Service

Both hydrocarbon and alkyd sections were in excellent condition on both day and night observation. Only one section in the southbound section (hydrocarbon) showed adhesion failure. This was the 2.8 mile section applied October 24, 1982, and is the only portion of the entire installation showing premature adhesion loss. The application for this section was not observed by laboratory personnel and was incorrectly reported as being wire brushed dry. Upon further inquiry it was learned that this section had been washed with detergent and apparently was not completely dry before the thermoplastic was applied. Although premature failures are disappointing, this one has been most valuable in showing that thermoplastic must be applied to absolutely dry surfaces. The use of detergent wash has since been eliminated as a surface precleaning method.

After 1 Year Service

The hydrocarbon section was still in good condition and providing good delineation, both day and night. No spalls or loss of adhesion were visible, apart from the premature failure due to application on the wet surfaces. The alkyd section in general was satisfactory, but some spalling and edge feathering were evident in one area three miles north of Pacific Coast Highway (SR1). No apparent difference could be detected between the primed and unprimed areas for either the alkyd or hydrocarbon thermoplastic.

After 2 Years Service

In the southbound hydrocarbon section, the lines were still in good condition with only a few minor spalls observed. No difference between the primed and unprimed sections was observed. The thermoplastic on the section from I-405 to SR1 was completely gone. As previously noted, this section started failing early due to wet pavement conditions during application of the thermoplastic.

In the northbound alkyd section, spalling and edge feathering were observed especially from I-405 to Del Amo Boulevard (2 miles). Excessive wear and spalling were also visible near the I-5 split and in the Brooklyn Avenue area. No difference between primed and unprimed areas was observed.

Night observation showed the alkyd and hydrocarbon thermoplastic both equal and satisfactory. Retroreflective intensity in both sections has decreased from the original by approximately 30%.

Surface Preparation

To draw definite conclusions as to which method of surface preparation to recommend is difficult. We know positively that detergent washing is unsatisfactory. Fiber brushing only removes loose debris, whereas the mechanical wire brush does an excellent job of not only removing loose material, but also abrades the surface and provides a rougher surface profile for bonding the thermoplastic. Observations do not lead to any positive conclusion that a primer is necessary on well aged concrete as long as the surface is clean and dry. The alkyd section near Brooklyn Ave does show some distress but this could be due to low material application temperature (370°F) at this location. This section was wire brushed and is also partially in a unprimed area. No other unprimed section showed poor performance. Too many variables are present at this location to be positive as to the cause of the distress.

Alkyd Operational Problems

Initial applications of the alkyd thermoplastic were made using material supplied in block form. Applications were satisfactory in the Long Beach installation and other locations in both Southern and Northern California. Most of the application problems with alkyd thermoplastic appeared after a granular form in meltable bags was introduced. Alkyd thermoplastic from one supplier caused considerable trouble during application in the main line Marcato applicator. The thermoplastic would not flow consistently through the ribbon guns especially on intermittent dash line application. The guns plugged up constantly and only operated during solid line application. This same material produced a scum which floated to the top of the thermoplastic melt. This scum was identified as bag material which did not appear to be compatible with the thermoplastic. Granular alkyd from another supplier presented no significant application problems, but laboratory control testing showed poor bond strengths, high hardness and low impact strengths. Nearly all subsequent use of thermoplastic has been the hydrocarbon type. A copy of the current hydrocarbon thermoplastic specification is shown in Appendix A as specification 8010-41G-21.

Revision of Thermoplastic Testing Methods

The thermoplastic testing method has been revised in an effort to duplicate melting and stirring conditions of full-scale application. Other tests have also been modified or added as described below. A copy of the test method is shown in Appendix B as California Test 423.

1. Meltdown and Stirring

The previous test method used 400 g of thermoplastic in a pint can, enclosed in a 425°F oven and stirred at 200 rpm with a shop-made stirring paddle powered by an electric motor and gear train. This type of agitation and heating was not representative of actual field conditions. To replace this method of meltdown and agitation, a Glas-Col heating mantle was employed which holds a 4000 ml stainless steel beaker. The heating mantle is wired to an electronic temperature indicator-controller with a digital readout. A thermocouple senses the required temperature and continuously displays the actual melt temperature. The controller-indicator is capable of maintaining the melt at 425±1°F for extended time periods. A 6000 g sample is used, which provides a more representative sample from a 50 lb bag or block. Agitation is done with a Lightning air-powered variable speed mixer with two A310 stainless steel impellers mounted on a 5/16 in. diameter shaft and operated at 800 rpm. This method of melting and agitation uses all "off the shelf" equipment and can be duplicated by anyone.

2. Viscosity

The viscosity of the melt is now specified in poises and measured by a Brookfield Thermosel Viscometer at 425°F. Two ranges of viscosity are specified; an extrude type with a range from 45 - 100 poises, for application with screed or ribbon gun and a spray type with a maximum viscosity of 30 poises for use with air-atomized spray guns. In previous specifications, a viscosity limit was not specified. The thermoplastic flow properties were specified as extrude, spray or as dual purpose spray-extrude type and the only test requirement was a limit on the residue from the stir-flow test. Dual purpose spray-extrude type thermoplastic simply was not compatible with all types of application equipment. Many field complaints were received when the spray-extrude type was used in screed applications where the plastic ran excessively from the screed shoe and under stencils used for legends and other pavement markings.

3. Tensile Bond Strength

On the sandblasted face of a concrete block 7 in. x 3.5 in. x 7 in., a 2.5-in.-wide x 0.125-in.-thick film of thermoplastic at 425°F is applied with a screed block. Before the thermoplastic sets, a 2-in.-diameter die with sharp edges is placed in the middle of the hot thermoplastic, held securely with one hand and the rest of the drawdown quickly scraped off with a spatula. The die is removed, leaving only a 2-in.-diameter by 0.125-in.-thick patty. After cooling, a 2-in.-diameter threaded aluminum cap is bonded to the patty with epoxy. The epoxy is allowed to cure overnight. The aluminum cap is threaded into a dynamometer and the total load at break is determined. This method is simple, results in a controlled thickness of the thermoplastic and gives very reproducible results. This method replaces the former method of using two concrete bricks bonded with thermoplastic in a cross pattern and then tested in tension on a dynamometer.

4. Impact Strength

The falling ball impact strength is done by drawing down a 0.125-in.-thick film of thermoplastic at 425°F, in the same manner as for the bond strength except that no patty is cut out. A Gardner falling ball impact tester is used with a 2-lb indentor. A minimum of 50 in.-lb is required with no cracks or loss of bond. This method replaces the Izod impact test which has been found to be unreliable. For example, the Izod requirement in the previous specification was a minimum of 25 in.-lb. We have found thermoplastics, especially some alkyds, which will pass the Izod test and yet fail the falling ball test at 10 in.-lb, with complete loss of bond.

5. Abrasion Test

An abrasion test has been added to give some idea of the wearability of the thermoplastic in lieu of actual road striping, a long, time consuming test. This test was developed by Bob Ryan of Cataphote-Ferro Corporation and basically consists of air blasting 25-30 mesh glass beads against the weighed sample of thermoplastic under controlled conditions and determining the weight loss. Mr. Ryan has correlated weight loss in the laboratory with actual field conditions. We have not verified the validity of this relationship, but believe that this method may be a means of screening out less durable materials.

6. Ultraviolet Resistance

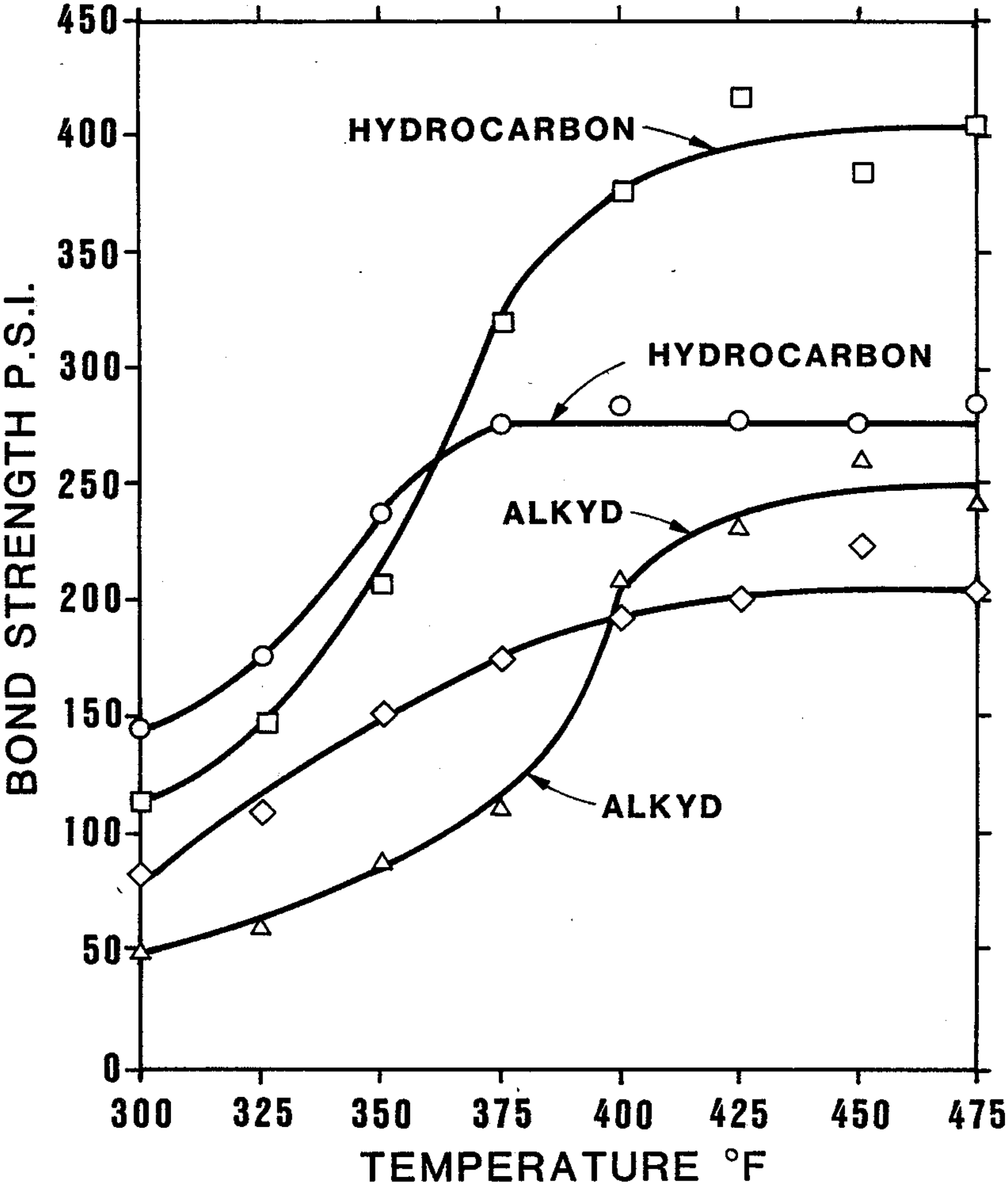
Since our specification is based on performance and not a compositional formula we do not specify limits on TiO_2 for the white thermoplastic and $PbCrO_4$ for yellow thermoplastic. We have added an ultraviolet resistance test for the yellowness index on the white after 300 hours accelerated weathering in the QUV (ASTM G53) and are also requiring the yellow plastic to meet FHWA specifications for hue, chroma and brightness after 300 hours in the QUV.

Comparison of Hydrocarbon and Alkyd Thermoplastic

Laboratory tests were conducted using alkyd and hydrocarbon thermoplastic from two vendors. Using the meltdown and test procedures described in the revised test method, the following relationships were determined:

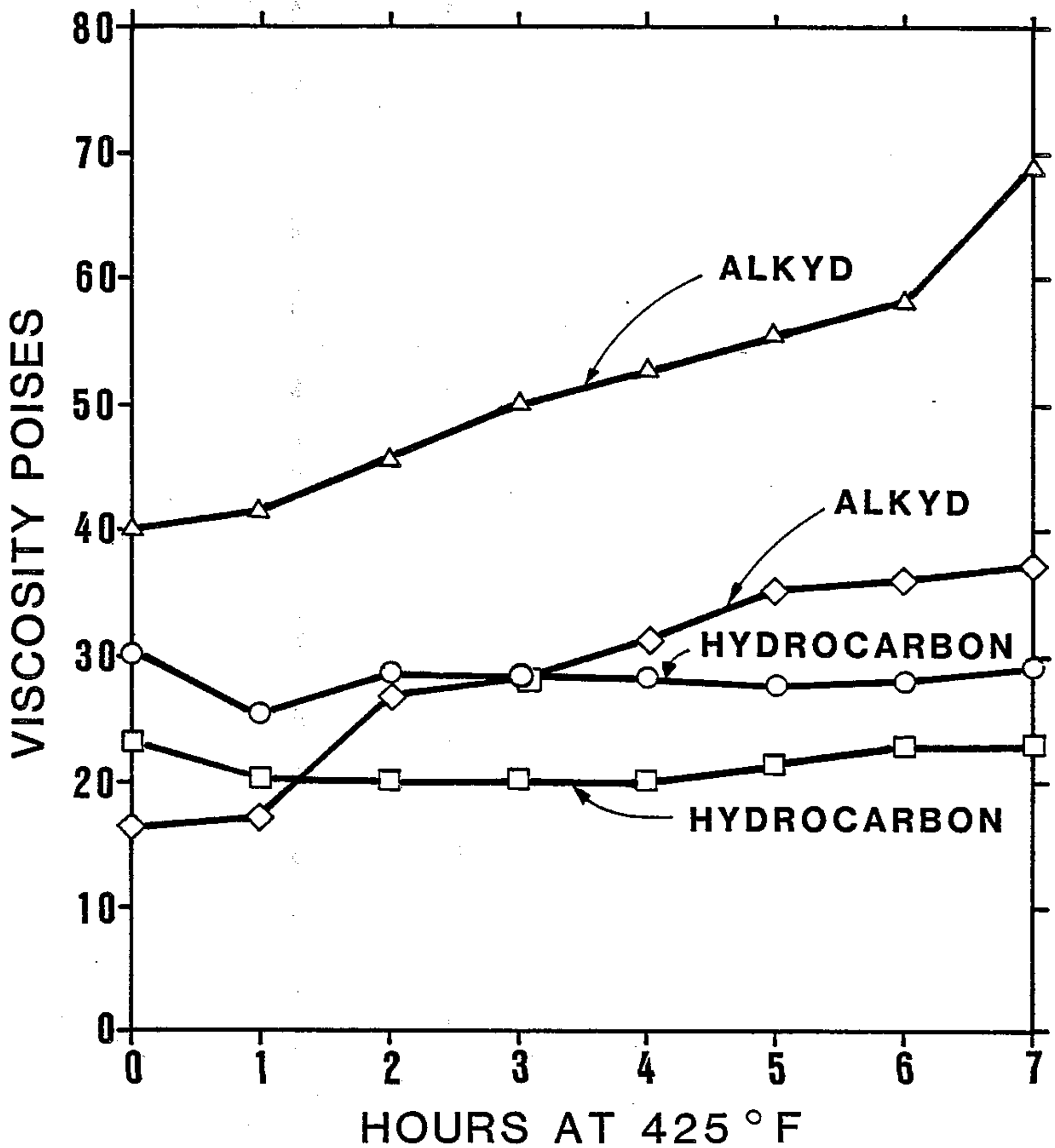
1. Variation of tensile bond strength to PCC at various application temperatures. Starting at 300°F, duplicate bond tests were prepared and determined at 25°F increments up to 475°F. This was done with two alkyds and two hydrocarbons from different suppliers. Results are shown in Figure 1.

2. Viscosity stability at constant temperature with time. This was determined by melting down a 6000 g sample according to the revised test method. When the temperature stabilized at 425°F, a Brookfield Thermosel viscosity was determined in poise. The molten thermoplastic was maintained at 425°F and agitated at 800 rpm. Viscosity measurements were made hourly. Results are shown in Figure 2.



TEMPERATURE VS BOND STRENGTH ALKYD & HYDROCARBON THERMOPLASTICS

Figure 1.



VISCOSITY STABILITY AT CONSTANT TEMPERATURE ALKYD & HYDROCARBON THERMOPLASTICS

Figure 2

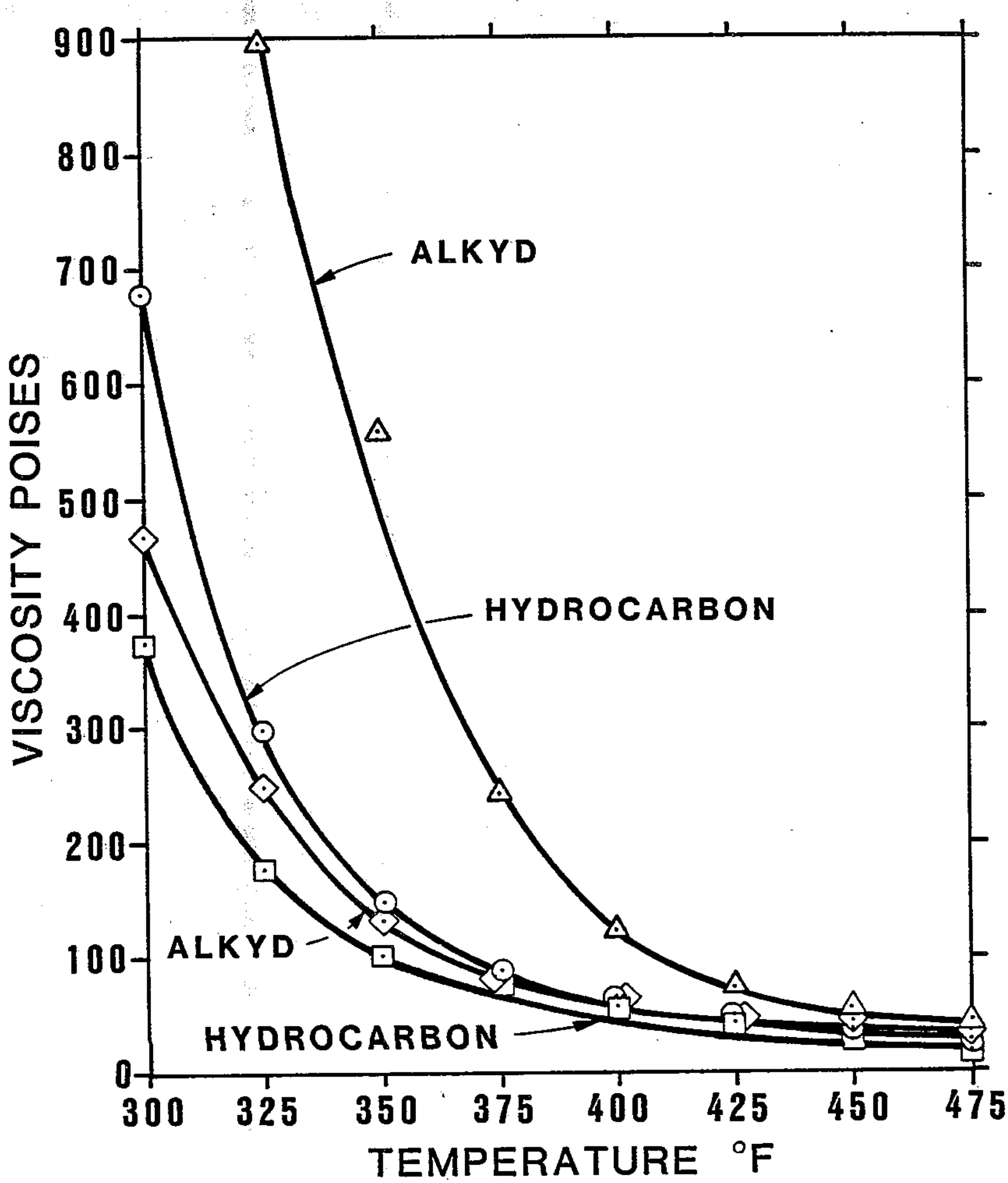
3. <u>Thermoplastic viscosity at various temperatures</u>. The Brookfield Thermosel viscosity was determined concurrently with the bond strength determination. Results are shown in Figure 3.

Summary of Lab Tests

1. Examination of Figure 1 shows that the hydrocarbon thermoplastics develop higher bond strengths than the alkyd type for all application temperatures. Below 400°F, the hydrocarbons show reasonable strengths of 200 psi even at 350°F, whereas the alkyds have much less bond strength at the lower temperatures. From this data, we would project that the alkyds should be applied at 425°F minimum and the hydrocarbons could be applied at 350 to 375°F without significant bond loss. The specification requirement for bond strength is 180 psi at 425°F, perhaps this value should be raised to 200+ psi.

2. Examination of Figure 2 shows a distinct difference in the viscosity stability of hydrocarbon and alkyd types. The hydrocarbon shows excellent viscosity stability over a 7-hour heating and stirring period. Viscosity stability is critical especially when thermoplastic is reheated and held at application temperature over a longer period of time than normal. This could be crucial during application with spray type thermoplastic where our specification requires 30 poises maximum viscosity. One of the alkyds in Figure 2 starts out at 16.5 poises and after 7 hours increases to 37 poises. This could cause poor spray application, especially if the thermoplastic were held overnight and reheated the next day. The viscosity instability of the alkyds in general is probably due to the chemical composition of the material. This could also account for the shorter shelf life of the granular alkyds as compared to the hydrocarbon.

3. Examination of Figure 3 shows a wide range of thermoplastic viscosities between 300°F and 475°F. The two alkyds and two hydrocarbons all have a viscosity at 425°F between 30 and 75 poises. At 350°F, two hydrocarbon and



BROOKFIELD THERMOSEL VISCOSITY VS TEMPERATURE ALKYD & HYDROCARBON THERMOPLASTICS

Figure 3

one of the alkyds (block type) show viscosities between 105 and 150 poises, whereas the other alkyd (granular type) shows a viscosity of 500 poises. The significance of this behavior is not understood, only that it is substantially different from the block type alkyd and both types of hydrocarbon thermoplastic.

Comparison of Zahn Cup and Thermosel Viscosities

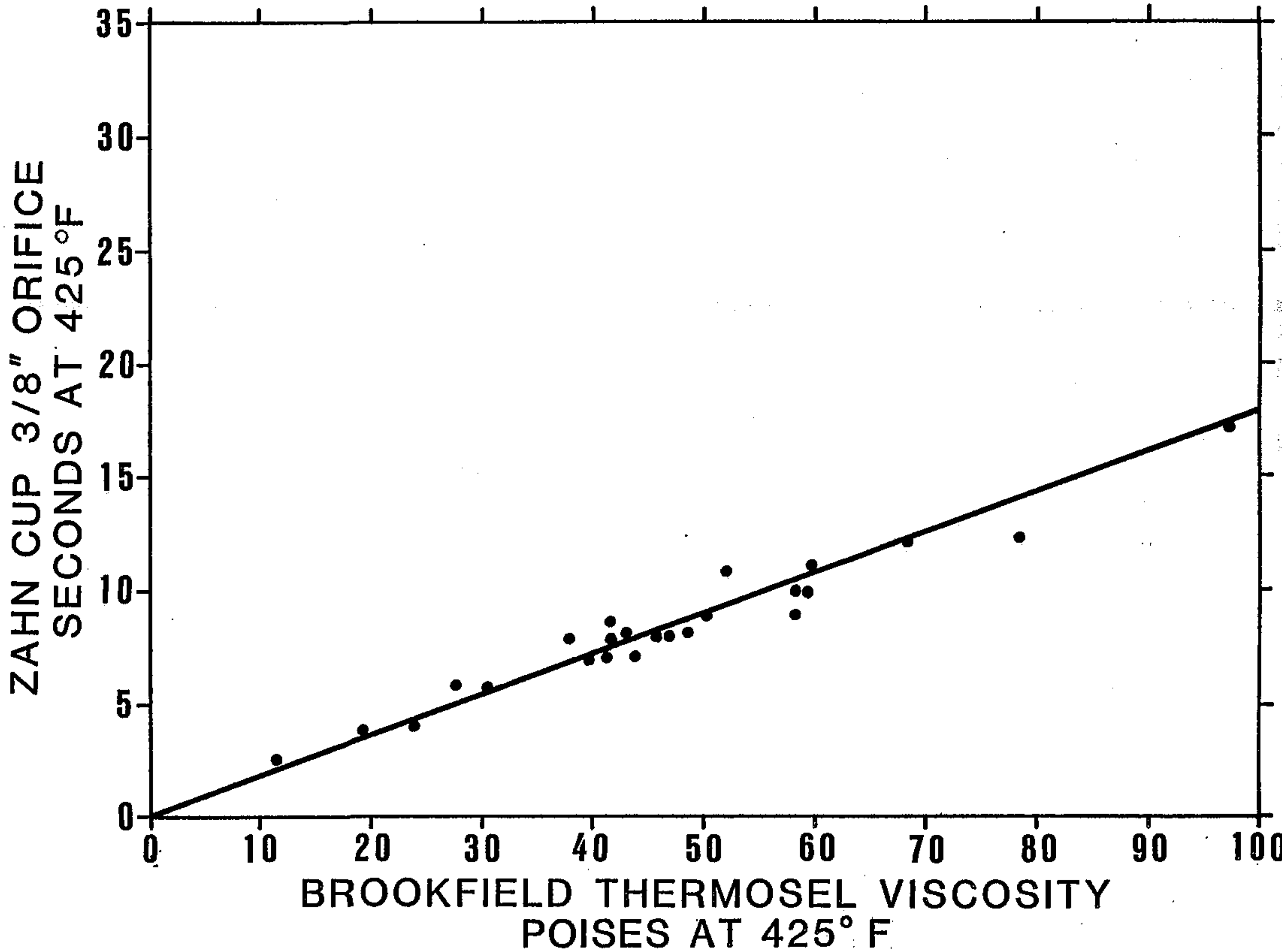
Some thermoplastic manufacturers use the No. 5 Zahn cup as a measure of viscosity. The No. 5 cup has a 0.208 in. diameter orifice. This is the largest orifice made and is too small for thermoplastic measurements, so the No. 5 must be enlarged. The cup used for our measurements was bored to a 3/8 in. (0.375 in.) diameter. We find the Brookfield Thermosel system to be far more accurate over a greater range and more dependable than the Zahn cup. The relationship between Zahn cup and Thermosel viscosities is shown in Figure 4.

F. Low Temperature Thermoplastic

Description and Properties

Lafrentz Road Services of Edmonton, Alberta, Canada, submitted 4 1/4 tons of their low temperature thermoplastic for our appraisal. This thermoplastic is used in Northern Canada and is reported to provide satisfactory performance. This material was subsequently surface-applied in the Kings Beach - Tahoe City area, elevation 6000 ft.

The Lafrentz thermoplastic is a hydrocarbon type and is very soft. The material is packaged in tin pails to prevent flow.



NO.5 ZAHN CUP WITH 3/8" ORIFICE VS BROOKFIELD THERMOSEL VISCOSITY, POISES AT 425°F

Figure 4

The quanties and types we received were as follows:

3 tons yellow, spray type, formula 034, viscosity 14 poises at 425°F.
1 ton of white, spray type, formula 036, vicosity 25 poises at 425°F.
500 lb of white, extrude type, formula 032.1, viscosity 225 poises at 425°F.

The recommended application temperature for the 034 formula was 350°F, the 036 formula was 356 to 410°F and for the 032.1 formula was 338 to 392°F. The application temperatures are substantially lower than our regular 425°F application temperature for thermoplastic.

This material was applied with the Marcato Mini Mac 1000 using ribbon guns for all applications. Application data are shown in Table 14.

Inspection After 3 1/2 Months

The Tahoe City section of yellow formula 034 was practically all removed by snowplow, chain and sand abrasion. The Kings Beach 4-lane section of white formula 036 was about 50% removed. Some lines were still intact, showing excellent adhesion and good bead retention. No evidence of spalling or loss of adhesion were observed. At the yellow formula 034 area of SR89 at Squaw Valley Road about 50% of lines were removed, but the remaining stripes were well bonded to the AC and very difficult to remove with a hammer.

Summary

Although 50% or more of the low temperature thermoplastic was lost, this material does show promise because the bond on the surviving stripes was excellent. The low surface temperatures of 45°F during the Tahoe City application and 33°F during the Squaw Valley Road application are not usually recommended for thermoplastic application. The usual minimum surface application temperature is 50°F and rising.

Table 14

Application Data For Low-Temperature Thermoplastic

Date	Color/ Formula	Location	Line Type	Temperature °F Air	Surface	Plastic	Pot psi	Thickness mils	Sample Location
10-5-83	White/ 036	SR28 Tahoe Vista To Brockway. 4 lane section north & south AC 2.4 miles	Dash	65	92	375	30	90	Beech St. North
								80	Franciscan North
10-6-83	"	"	Dash	51	51	410	15	80	28 Pla 8.00 South
		"	"	"	"	"	"	90	28 Pla 8.73 South
		"	"	"	"	390	"	80	Beech St. South
		SR28-SR267 Jct AC	Left Turn Pocket	"	"	"	"	80	
10-6-83	White/ 032.1	SR28-SR89 Jct New AC	Edge and Dash	65	70	430	40	100	High Viscosity-Raise Temp and Increase Pot psi
10-12-83	Yellow/ 034	SR89, 0.10 miles from SR28 Tahoe City	Double Yellow	61	63	430	15	100	Plastic too hot-run
	"	SR28 Tahoe City	2-Way Left Turn Lane	61	63	350	25	70	SR28 & 89 Operation OK
10-13-83	"	SR28 From Fairway Drive to Fabian 3 miles AC	Dash & Double Yellow	45	45	375	25	70	SR28 & 89
				45	45	375	25	65	Safeway Store
				50	52	375	20	60	Star Harbor Road
				50	52	375	20	60	Lake Forest Road
10-14-83	"	SR89 Squaw Valley	Turn Lanes	33	33	375	15	70	

The lower application temperature (375°F) could be an economic factor in fuel savings due to quicker meltdown in the premelters. This type of thermoplastic, in spite of the failures, has shown more suitability to snow environment than the regular hydrocarbon types.

We may conclude from results of these test installations and others in the snow area where steel blade snowplows removed snow and ice to bare pavement, that surface application of thermoplastic is not adequate for the severe service to which the coating is subjected in the mountain areas. Inlaying the coating appears to be the only solution for this type of environment.

G. Inlaid Thermoplastic

Grooving

To determine the feasibility of inlaid thermoplastic traffic stripes, State Route 203 at Mammoth Lakes, California, was selected for testing. Mammoth Lakes, at 8000 ft elevation, is a popular winter recreational area with heavy snowfall and roads subject to the abrasive action of snowplow, chains, salt, sand and cinders.

The AC on SR203 was about 2 years old and showed considerable exposed aggregate from chain and snowplow action. In the fall of 1982, the grooving was completed by contract. Minimum depth of all the grooves was 3/8 in. The broken stripes were cut 4 in. wide and 7 ft long. Grooves for the left and right turn pockets, stop bars and traffic islands were cut 8 in. wide.

The cost of grooving was $2.00 per lin ft, 4 in. wide and 3/8 in. deep. Unfortunately, early snowfall delayed the thermoplastic application until the fall of 1983.

The following low temperature white thermoplastics were used for inlaying:

Pavemark, alkyd, W5C-3BX-CD
Lafrentz, hydrocarbon, 032.1 (Canada)
Cataphote, hydrocarbon, 921-WGA-000E
Interprovincial (MLE), hydrocarbon (Canada)
Pavemark, hydrocarbon, regular California specification.

All application was done on SR203 from post mile 5.9 to 4.5. Thermoplastic from each supplier was divided so that each had application on broken line and right and left turn pockets. A total of 1250 lb from each supplier was used.

Application of Thermoplastic

Actual application took place September (13-22) 1983. All grooved lines were blown clean with compressed air and thermoplastic was applied with a screed shoe and release coated stencils for the broken lines and a screed shoe without stencils for the 8 in. wide applications. The objective was to fill the grooves to or slightly below pavement level. At the Bus Stop Restaurant on SR203, three Stimsonite 947 reflective markers were imbedded in the hot plastic on alternate stripes. The markers were installed so that the top surface was at or below the pavement level. Four more markers were placed in the same manner by the Red Rooster Mall. No thermoplastic was applied in the yellow centerline, however, short grooves were sawed into the centerline as a guide for relocation of the regular paint stripes.

Average ambient temperatures during application ranged from 60 to 80°F and surface temperatures ranged from 67 to 118°F. On September 22, 1983, during the Interprovincial application, some light rain fell in the early morning but by 10:00 a.m. the surface was dry. As a further precaution, the grooves were dried with a propane torch. Thermoplastic application temperature averaged 400°F.

Inspection After Eight Months

After eight months exposure, including one full winter, all of the test installations were still providing good daytime and nighttime delineation. The standard Pavemark hydrocarbon had become brittle and was spalling at all locations. Both the Pavemark and Cataphote low-temperature hydrocarbon had transverse cracks in the broken lines and the 8 in. wide lines. Cracking was absent in the Pavemark alkyd, Lafrentz and Interprovincial low-temperature material. All lines had darkened due to traffic staining. Pavemark alkyd thermoplastic had darkened the least and Lafrentz hydrocarbon the most. Bead retention in all formulations was satisfactory.

The Stimsonite 947 low profile reflective markers that were installed in the hot thermoplastic were badly damaged by the snow plows and chains. All the markers had damaged faces, however, the remaining parts of the markers were still firmly embedded in the thermoplastic.

Summary

Based on the results of this limited test, it appears that inlaid thermoplastic striping is feasible and is the only type of coating we have found to survive the winter months in snowplow areas. The type of thermoplastic used has a great deal of bearing on the durability of the line. The thermoplastic must be able to withstand freeze-thaw conditions to prevent cracking and bond loss.

A more extensive installation was planned for the fall of 1984, but due to lack of district funding it was deleted.

The cost of grooving for the initial installation was $2.00 per lin ft, 3/8 in. deep and 4 in. wide. Adding the thermoplastic cost of approximately $700 per ton would increase the total grooving and material cost to $2.44 per lin ft. This of course is expensive, but inlay installations could be used in critical mountain areas and may prove cost-effective, if the life expectency were several years.

More extensive grooving and inlaying with low temperature thermoplastic has been planned for the summer of 1985.

WATER-BORNE TRAFFIC PAINT

Background

Preliminary laboratory work and field applications of water-borne traffic p-paint were described in Interim Report FHWA/CA/TL-83/03 dated January 1984. This work showed the water-borne system to be a viable alternative to solvent-borne coatings with equal or better durability and increased bead retention. This work also provided enough data for the writing of an initial specification.

Initial Specifications

In January 1983, specifications for two types of water-borne traffic paints were published, a rapid dry and a regular dry type. Both types called for 100% acrylic vehicle. The rapid dry type, PTW1 white and PTW2 yellow, was for heated application through the existing kinetically heated airless paint stripers. The regular dry type, PTW3 white and PTW4 yellow, was for cold application through the older air atomized units. No water-borne black was included in these first specifications. The specifications are included in Appendix A.

In the summer of 1983, 30,000 gal of regular dry paint was purchased from J. E. Bauer Paint Co., Los Angeles, California, and another 30,000 gal of rapid dry paint was purchased from Baltimore Paint and Chemical, Baltimore, Maryland.

Application of Rapid Dry

Initial attempts to apply the rapid dry through the hot striper using the kinetic heater were not too successful. Part of the problem was due to the paint and part due to the plumbing of the striper. The hot striper uses Roper gear pumps to load the paint into the striper from the 55 gal drums, the same pumps are used to feed the kinetic heater and high pressure airless paint pumps. Even during the loading operation, the Roper pump would seize up or run intermittently. Part of this problem was due to the presence of fine skins in the paint itself. These skins were difficult to detect since they were dispersed throughout the paint and not just localized on the surface where skinning is usually apparent. It was necessary to install fine screens over the intake tube during loading operation to separate the skins. This procedure reduced the problem with the Roper pump seizing, but did not entirely cure the poor paint application which was evidenced by plugged gun tips, high pressure pumps jamming and gelation of the paint. The Roper gear pump, being a positive displacement pump, would build up excessive pressure in the lines to the heater and high pressure paint pump causing the emulsion to gel. Regulating the amount of paint to supply the requirements of the heater and high pressure pumps was difficult. To remedy this situation, a pressure bypass was fitted into the Roper output so that excess paint, not required by the heater and high pressure pump, was recirculated back to the paint storage tank. This procedure enabled the balance of the rapid dry to be successfully applied.

Operational application of the rapid dry water-borne paint was observed and application data are shown in Table 15.

Date of Application	Dec. 5-8, 1983
Application Unit	CHC 439, Hot Striper
Paint	Baltimore Rapid, White & Yellow
Location	SR 34, Ventura County from Junction of SR1 (Oxnard Blvd) to Junction of SR 118 in Somis. Also part of SR 126, between Fillmore, Ventura County and Junction of SR 23.

Application Notes

No problems attributable to the water-borne paint were encountered. The application of the paint was very satisfactory, even when the kinetic heater was used to heat the paint before it was applied.

Table 15

Baltimore Rapid Dry Traffic Paint
Water-Borne

Application Data

Location	Date	Line Type	Temperature °F Air	Surface	Paint	% R.H.	Lbs Beads Per Gal	Dry Paint Thickness Inches	No Track Time Minutes	Sample Location
SR34, Camerillo	12-5-83	Edge	67	73	125	46	3.1	0.005	2	34 VEN 15.00 East
Jct 101,east & west	"	Edge	"	"	"	"	3.9	0.006	2	34 VEN 17.50 East
to Jct SR118 AC	"	Edge	"	"	"	"	1.8	0.006	2	34 VEN 17.50 West
	"	8" Turn	"	"	"	"	-	-	2	
	"	Pockets	"	"	"	"	-	-	2	
		Rice St.								
		Adolfo Rd.								
		E.Elma St.								
		8" Turn								
SR34 from San Pablo	12-6-83	Pockets	65	73	125	45	-	-	2	
to Merritt Ave	"	"	"	"	"	"				
Camerillo	"	Edge	"	"	"	"	2.6	0.005	3	34 VEN 11.50 West
SR34 west from	"	Edge	"	"	"	"	2.5	0.005	3	34 VEN 8.50 West
Jct 101 to Oxnard	"	"	67	75	125	45	2.7	0.006	2-1/2	34 VEN 7.00 West
Blvd (SR1)										
SR34 east from	"	"	"	"	"	"	3.5	0.006	2	34 VEN 5.50 East
Oxnard Blvd to	"	"	"	"	"	"	2.9	0.006	2	34 VEN 7.30 East
3M Plant										
SR34 east from	12-7-83	Double	68	75	125	65	2.7	0.006	4	34 VEN 7.30
Oxnard Blvd to		& Dash								
to 34 VEN 9.50		Yellow								
		Centerline								
SR34, Pleasant	12-8-83	Double	55	56	125	71	3.1	0.006	5	34 VEN 8.91
Valley Road to	"	& Dash	64	66	125	57	2.8	0.006	3	34 VEN 12.54
SR118	"	Yellow	72	77	125	46	2.6	0.006	3	34 VEN 15.00
SR126, Fillmore	"	Yellow	72	77	125	46	2.6	0.006	2	SR126 & Clay
from Jct SR23 east	"	2-way	"	"	"	"	2.9	0.006	2	126 VEN 22.74
to 125 VEN 23.16		Left,								
		Double								
SR126, Fillmore	"	Yellow	"	"	"	"	-	-	2	
from Jct SR23 west		2-way								
to 126 VEN 20.00		Left								

Film thickness of the white and yellow paint was consistent at 0.006 in. (6 mils) dry or 0.010 in. (10 mils) wet. For a solid single 4-in. stripe, this represents 12.0 gal per mile. Striper speeds with 1 paint gun averaged 11 mph and with 2 paint guns 20 mph.

Initial glass bead retention averaged 3 lb beads per gal of paint. This figure is typical for the hot stripers which do not have sufficient bead flow. For example, using the same paint applied with the laboratory hot striper a bead loading in excess of 9 lb/gal is easily obtainable. Even though the bead loading was low in full-scale application, the beads that were retained were well embedded throughout the paint film.

Dry times for the white and yellow paint were excellent. At 45% relative humidity, ambient temperatures from 65 to 68°F, surface temperatures from 70 to 75°F, and the paint at 125°F, the dry times were from 2 to 3 minutes. When the humidity was 65-70%, the dry time increased to 5 minutes.

Loading time of the paint from the 55 gal drums averaged 75 seconds or 44 gpm. Drums were completely emptied with no residue except for some skins which were removed by the intake screen.

As noted before, the presence of skins throughout the paint caused problems. Subsequent batches, however, were in good condition and only a minor amount of skinning was observed.

Application of Regular Dry

Operational application of the regular dry water-borne paint was observed and application data are shown in Table 16.

Date of Application	November 15-17, 1983
Application Unit	CHC 433, Hot Striper
Paint	Bauer Regular Dry, White & Yellow Cold applied, Heater bypassed
Location	SR 86 and SR 111 in Indio, Riverside County.

Table 16

Bauer Regular Dry Traffic Paint
Water-Borne

Application Data

Location	Date	Line Type	Temperature °F Air	Surface	Paint	% R.H.	Lb Beads Per Gal	Dry Paint Thickness Inches	No Track Time Minutes	Sample Location
SR111, Indio, north 1.3 mi. from Jct SR86	11-15-83	Double Yellow Centerline	74	75	cold	53	-	-	5	-
SR111, Thermal 111 Riv 16.50	"	Double & Single Solid Yellow	76	85	cold	35	-	-	5	
SR111, north from 111 Riv 21.00 to Ave 48	"	Edge	87	97	cold	25	2.8	0.006	5	111 Riv 22.00 North
	"	"	"	"	"	"	2.7	0.006	5	111 Riv 26.00 North
SR86, South from Ave 54 to 86 Riv 4.00	"	Edge	86	98	cold	25	5.4	0.006	4	86 Riv 17.00
	"	"	"	"	"	"	5.6	0.006	4	86 Riv 4.00
Jct SR 86 & SR111, Indio south to Ave 54 & north to Jct 86 & 111 in Indio	11-16-83	White Dash	70	70	cold	45	4.6	*0.003	5	*86 Riv 19.00 North Filter Plugged
			"	"	"	"	3.3	*0.004	4	*86 Riv 22.00 North Filter Plugged
SR86 north from Ave 54 to Ave 48	"	White 8" Left Turns	80	85	cold	35	-	-	4	
SR86 south from Ave 48 to Ave 54	11-17-83	White 8" Left turns	74	80	cold	64	-	-	15	
SR86, south from 86 Riv 4.00 to 0.00	"	Edge	"	"	"	"	2.4	0.006	15	84 Riv 3.00 South
SR86, north from 86 Riv 0.00 to 8.00	"	"	74	80	cold	65	2.4	0.007	15	86 Riv 1.00 South
	"	"	"	"	"	"	3.4	0.007	15	86 Riv 4.00 North

Application Notes:

The paint was applied cold with the kinetic heater bypassed. Application was satisfactory with no problems attributable to the water-borne paint. Film thicknesses averaged 0.006 in. (6 mils) dry or 0.010 in. (10 mils) wet. This represents 12.0 gal per mile of single solid 4-in. stripe; with 1 paint gun, striper speed averaged 11 mph.

Initial bead retention averaged 3.6 lb beads per gal of paint.

Dry times for the white and yellow averaged 4 to 5 minutes at relative humidity of 25%, ambient temperatures 75 to 85°F and surface temperatures 85 to 98°F. When the relative humidity increased to 65%, the dry time increased to 15 minutes.

Loading time of the paint from the 55 gal drums was 70 seconds or 45 gpm. The drums were completely emptied with no residue or skins.

Summary

Operation with water-borne traffic paints through the hot striper is operational and should present no problems. Modifications of the District 7 hot striper appear to have remedied the earlier application problems. By-passing a proportion of the Roper output to the top of the paint tank has relieved the pressure buildup in the feed line from the Roper pump to the heater and paint guns. Since they are emulsions, water-borne paints are not as stable as conventional solvent-borne paints and should not be subjected to excessive high shear and pressure. Water-borne paint has more tendency to skin and the practice of putting screens over the intake tube when loading paint should be continued. The rapid dry water-borne paint appears to be more sensitive to heat, shear and skinning than the regular dry type. However, the faster drying characteristics of the rapid dry type and tolerance to higher humidity makes the rapid dry a better production coating than the regular dry type.

Future Equipment Modifications

Future water-borne paint stripers will have a heat exchange method of indirect paint heating using glycol or other heat exchange medium. These units will replace the kinetic heaters. The Roper gear pumps will be phased out and replaced with diaphragm pumps. All paint tanks will be stainless steel and the paint application package will consist of airless type guns and pumps.

A new MB commercial striper has been purchased and is operational in the Los Angeles area and will be used solely for the application of water- borne traffic paint.

Qualified Products List

The PTW1-2-3-4 water-borne specifications, although essentially performance type, did limit the vehicle type to acrylic polymer and placed limits on density, pigment and total solids. To provide the formulator with more choice and to stimulate use of new emulsions and technology, these restrictions concerning vehicle type, density, pigment and total solids were removed. The requirements for dry time, viscosity and volatile organic compounds (VOC) level still must be met.

Vendors interested in bidding are required to submit their paints for qualification. Their paint must pass all specification requirements before they are allowed to bid. In 1984, eight vendors submitted samples for qualification and only two were able to meet all the requirements. This specification was designated as 8010-32F-30, Rapid Dry, White and Yellow. The regular dry type was discontinued due to field reports that the PTW3 and 4 was too slow in dry time, especially during periods of high humidity or cooler weather. A copy of 8010-32F-30 appears in Appendix A.

Water-Borne Contract - 1984

Bidding between the two vendors on the QPL list, Bauer and Baltimore, resulted in Bauer being awarded the water-borne contract for 240,000 gals of traffic paint. Bid prices, delivered in 55 gal drums were:

White $5.25/gal
Yellow $5.35/gal
Black regular dry $4.25/gal.

These prices are about $1.00/gal over the cost of solvent-borne traffic paint.

Batch sampling and laboratory analysis indicate good compliance with specifications. Field reports on application of water-borne traffic paint from Los Angeles, El Centro and Stockton have been good with satisfactory application properties and dry times.

The majority of the rapid dry water-borne paint has been used in the California hot striper with a kinetic heater and airless spray guns. The Stockton district (Northern California) has used unheated rapid dry paint in both the hot striper and in an old air atomized striper using Binks 21 guns and reports most satisfactory results. The average viscosity of the rapid dry paint has been 80 KU which probably accounts for the good air atomized operation.

On September 3, 1984, a new paint striper was put into operation in the Los Angeles district. The striper was made by MB Company in Wisconsin. This unit will be used for the application of water-borne traffic paint exclusively. Paint capacities of the striper are 300 gal white, 300 gal of yellow and 150 gal black. All tanks are stainless steel. Wilden diaphragm pumps are used to load the paint from the 55-gal drums at about 20 gpm, and also to supply the Viscount hydraulic paint pumps. Airless guns are used for paint application. The unit has a multiple-pass boiler-type heat exchanger using glycol as the heat exchange medium. Paint may be applied from either side using hydraulically operated gun carriages. Approximate cost of the unit was $175,000.

Reports from the field have indicated that water-borne traffic paint is more abrasive than solvent type, especially on spray gun tips. If only the replaceable carbide tips are showing wear, then this is not too serious a problem, since the tips are relatively inexpensive as compared to a pump. We have requested our maintenance districts that are using water-borne paint to watch for any abrasion problems and to document any excessive wear. This applies especially to the new MB striper.

LABORATORY TESTING WATER-BORNE PAINTS

Scrub Resistance

During our prebid qualification testing it was found that the successful paints all had scrub resistance values (ASTM D2486) well in excess of the 400 cycle minimum required in the specification. Scrub resistance values ranged from 1200 to 2100 cycles. In the road service test portion of the specification, in which transverse stripes are applied to evaluate the wearability, rain occurred 12 hours after application. On examination the following morning, it was observed that the paints least affected by the traffic were the ones with the high scrub resistance values. Subsequent scrub resistance tests where the paint film was allowed to cure only 24 hours at 75°F before testing again showed the same paints to have scrub resistance of 1000 to 1850 cycles even without the heat cure of 24 hours at 120°F. As a result of this improving technology in water-borne paints, we anticipate raising the scrub resistance requirement to 800 cycles and decreasing the cure time to 24 hours at 75°F.

Ultraviolet (UV) Resistance

All the white water-borne paints submitted for prebid testing were subjected to ultraviolet and condensation accelerated weathering (ASTM G53) using FS40 lamps on a 4h UV/60°C; 4h CON/40°C cycle. The yellowness index was determined both before and after 620 hours total time. The yellowness index values were very good, ranging initially from 2 to 7. After 620 hours, the values remained remarkably constant with only one paint increasing to 16, all the others remained well under the specification limit of 10.

To determine the yellow color more precisely, the qualifying yellow paints were run on the QUV (ASTM G53) 4h UV/60°C; 4h CON/40°C cycle, FS40 lamps for a total time of 300 hours and plotted on CIE chromaticity charts. Before and after UV exposure the paints were found to lie within the limits of hue, chroma and brightness according to the highway yellow color chart PR#1, FHWA. These requirements will be added to future specifications.

Flash Point

Most of the Qualified Products List (QPL) paint samples submitted had flash points (Pensky Martins closed cup) in excess of 100°F. Some paints we have evaluated have had flash points as low as 50°F. Since shipping regulations require a Flammable label on material with a flash point below 100°F, the flash point on future specifications will be set at minimum 100°F. This will shift the shipping requirement to combustible and should reflect lower freight and insurance rates.

QPL List 1985

A revised specification for rapid dry water-borne white and yellow and black traffic paints has been issued as 8010-42L-30. A black rapid dry was added to replace the regular dry black. The black is used as a contrast stripe between two yellow stripes, and it had been observed that the rapid dry yellow stripes would be dry to a no-track condition whereas the regular dry black was still wet and traffic would track the black paint over the yellow. Other changes in the specifications include raising the scrub requirement to 800 cycles, adding a 100°F minimum flash point and UV resistance requirement. The specification is included in the Appendix A.

Two more vendors have qualified for the 1985 QPL list, making a total of four. These are Bauer Paint Co., Los Angeles, California; Pervo Paint Co., Los Angeles, California; Norris Paint Co., Salem, Oregon, and Sherwin Williams, Baltimore, Maryland. With more qualified bidders, we anticipate very competitive bidding and perhaps decreased prices for the next contract.

Lead-Free Water-Borne Traffic Paint

Background

The initial research and testing of lead-free yellow traffic paints was reported in Report No. FHWA-CA-TL-78-18 entitled "Develop and Evaluate a Substitute for Chrome Yellow in Yellow Traffic Line Stripes", dated June 1978.

The vehicle used in the study was a solvent-borne system containing alkyd-chlorinated rubber resins. Although the yellow color could be matched, the light fastness of even the most promising systems was not adequate to withstand outdoor exposure in the Southern California desert test area.

American Hoechst Lead-Free Yellows

Since the initial lead-free yellow paints failed to show color stability in the California desert, we have continued to work with American Hoechst in Conventry, Rhode Island, in their effort to develop satisfactory lead-free yellow pigments. In March 1983, Hoechst submitted a series of lead-free yellows in an alkyd solvent-borne vehicle. The pigmentation of these paints was as follows, in lb pigment per 100 gal paint:

Quality No. 3	32.76 lb 11-2514 Hansa Yellow 3GX-02-T
	12.44 lb 11-3203 Permanent Yellow YR-T
	1.88 lb Yellow Oxide (201ED or YLO 2288B)
Quality No. 3L	17.63 lb 11-2514 Hansa Yellow 3GX-02-T
	7.89 lb 11-3203 Permanent Yellow YR-T
	1.00 lb Yellow Oxide (201ED or YLO 2288B)
	26.02 lb TiO_2 (RCL-9 or equal)
Quality No. 4	16.78 lb 11-2514 Hansa Yellow 3GX-02-T
	26.84 lb 11-2301 Hansa Yellow R-T
Quality No. 4L	8.76 lb 11-2514 Hansa Yellow 3GX-02-T
	14.12 lb 11-2301 Hansa Yellow R-T
	11.93 lb TiO_2 (RCL-9 or equal)
Quality No. 8	32.17 lb 11-2400 Hansa Yellow X-T
	4.70 lb 11-3203 Permanent Yellow YR-T
	16.43 lb TiO_2 (RCL-9 or equal)

Quality No. 8L	17.24 lb 11-2400 Hansa Yellow X-T
	0.75 lb 11-3203 Permanent Yellow YR-T
	17.98 lb TiO_2 (RCL-9 or equal)
Quality No. 9	30.40 lb Experimental Yellow S6-296
	7.01 lb 11-2514 Hansa Yellow 3GX-02-T
	3.75 lb Yellow Oxide (201ED or YLO 2288B)
	9.35 lb TiO_2 (RCL-9 or equal)

Pigmentation for Quality No. 9L was not available. The L designation on all formulas means a lighter tint.

Field Exposure

The lead-free yellow paints were applied to the AC median on Interstate 8 at PM 41.00 near El Centro on March 22, 1983. For control, a fast dry solvent-borne yellow (8010-31J-05) was used. This specification is shown in Appendix A. The control yellow has a medium chrome yellow loading of 0.75 lb/gal. The stripes were 4 ft long and 4 in. wide and were applied with a paint brush.

Lead-Free Yellow - 7-Month Inspection

All the Hoechst yellows, Quality No. 3 through No. 9L have failed in light fastness as compared to the lead chromate control. All lines were faded such that a yellow color was not recognizable, only the lead chromate control remained a positive yellow color.

QUV Exposure Lead-Free Yellows

The Hoechst yellows No. 3 through No. 9L were tested for ultraviolet radiation resistance according to ASTM G53 using FS40 lamps . The panels were exposed for 660 hours in the QUV apparatus, using a cycle of 4 hours UV exposure at 60°C and 4 hours condensate exposure at 40°C. Chromaticity values of Y, x and y obtained before and after exposure are listed in Table 17 and plotted in CIE coordinates in Figure 5. A portion of the chart has been masked off to show points more clearly. These results correlate very closely with the field exposures in El Centro. As shown in Figure 5, the only sample that stayed within the color limit area was the lead chromate control, labeled C for original and CX after exposure, all the test yellows drifted considerably from the yellow color limit area.

TABLE 17

Chromaticity Values Organic Yellows - 660 Hrs QUV

Sample	Y		x		y	
	Original	Exposed	Original	Exposed	Original	Exposed
Control	57.7	50.8	0.496	0.494	0.464	0.460
No. 3	47.8	51.5	0.499	0.471	0.454	0.450
No. 3L	53.7	57.1	0.493	0.460	0.454	0.444
No. 4	49.2	53.0	0.495	0.464	0.453	0.444
No. 4L	55.8	60.7	0.474	0.437	0.458	0.438
No. 8	53.1	56.0	0.500	0.467	0.452	0.441
No. 8L	57.0	59.6	0.478	0.440	0.456	0.435
No. 9	47.7	50.4	0.501	0.468	0.454	0.440
No. 9L	57.9	60.0	0.484	0.450	0.456	0.434

Lead-Free Yellow - 1984 Tests

As a result of our continued interest in lead-free yellows, two more formulations were submitted by Hoechst. These were formulated using both a solvent alkyd and a water-borne emulsion formula. These paints were designated as Quality No. 10D, Solvent-Borne, Quality No. 10D, Water-Borne; Quality No. 11D, Solvent-Borne and Quality No. 11D, Water-Borne.

Field Exposure

These lead-free yellow paints were applied April 2, 1984, to the AC median on Interstate 8, near El Centro in the same location as previous tests. A

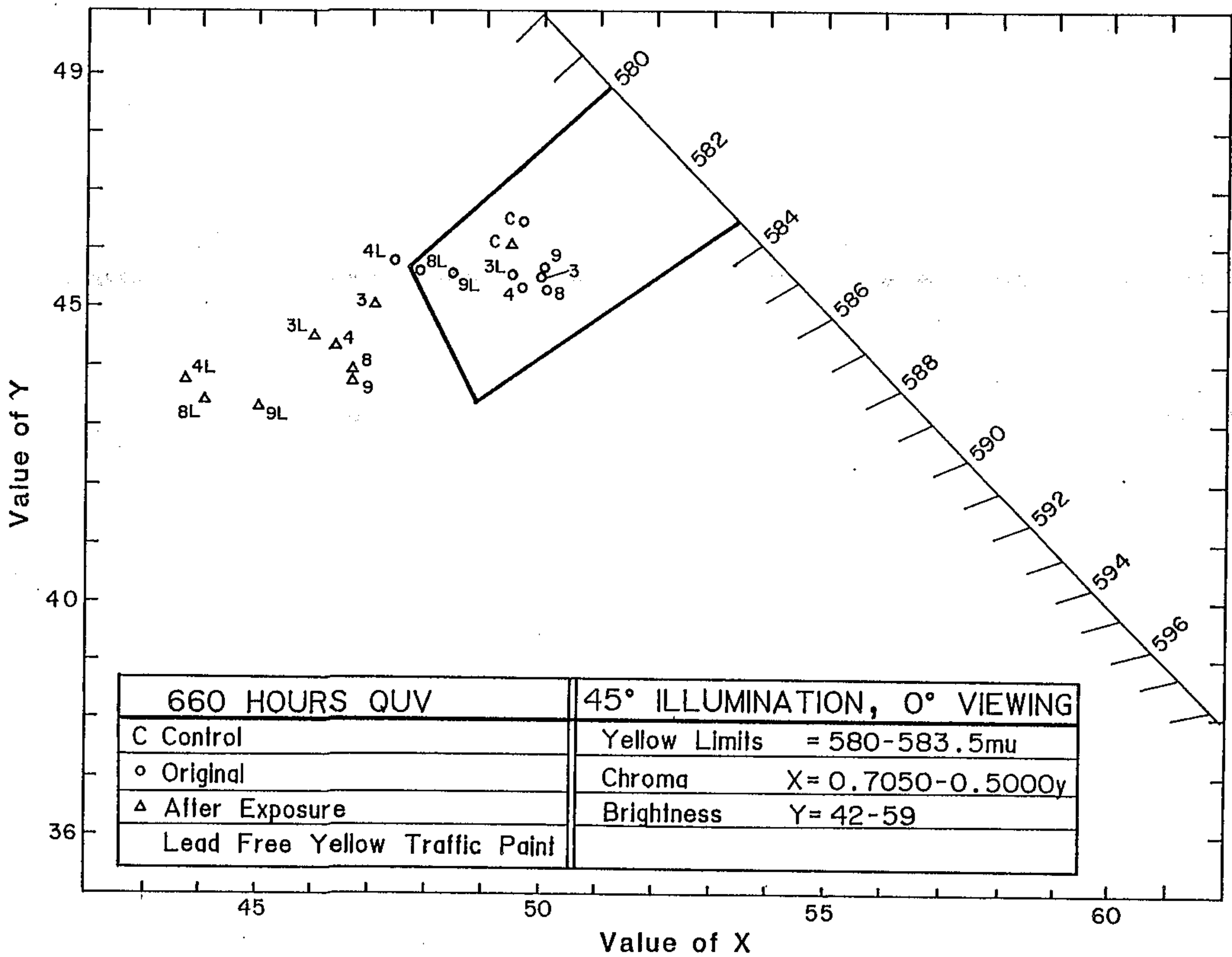


Figure 5 HUNTER COLOR DIFFERENCE METER

solvent-borne yellow was used as control. About two months later, this test section was covered over with a slurry seal, so no field evaluation was made.

Fortunately, extensive accelerated laboratory testing according to ASTM G53 (4h UV60°C/4h CON40°C) was done. The results of the accelerated testing were most interesting. As plotted in Figure 6, the control as usual remained stable but the 10D solvent-borne and the 11D solvent-borne failed whereas the water-borne versions containing the same pigmentation remained within the color limit area for 952 hours of test. The solvent-borne formulas actually failed after 240 hours of exposure.

Because of the loss of the field test lines and since the ASTM G53 UV-Condensation Test has shown good correlation with the outdoor exposures, it was decided to operationally test the 10D formula in a water-borne emulsion. This pigmentation consists of a blend of organic yellow color index number 75, organic yellow color index number 10 and yellow iron oxide. Sherwin Williams, Baltimore Division will be manufacturing 550 gallons of water-borne yellow at a delivered price of $5.25/ gal. Hoechst has agreed to defray any additional difference in manufacturing cost to produce this paint. The paint was ordered by District 11 and was applied in the desert area in June 1985.

If operational testing is satisfactory and good light stability can be realized, then the current water-borne traffic specification will be revised to include lead-free yellow paint. The use of lead-free yellow pigments in our water-borne specification should increase the use and interest in water-borne traffic paints.

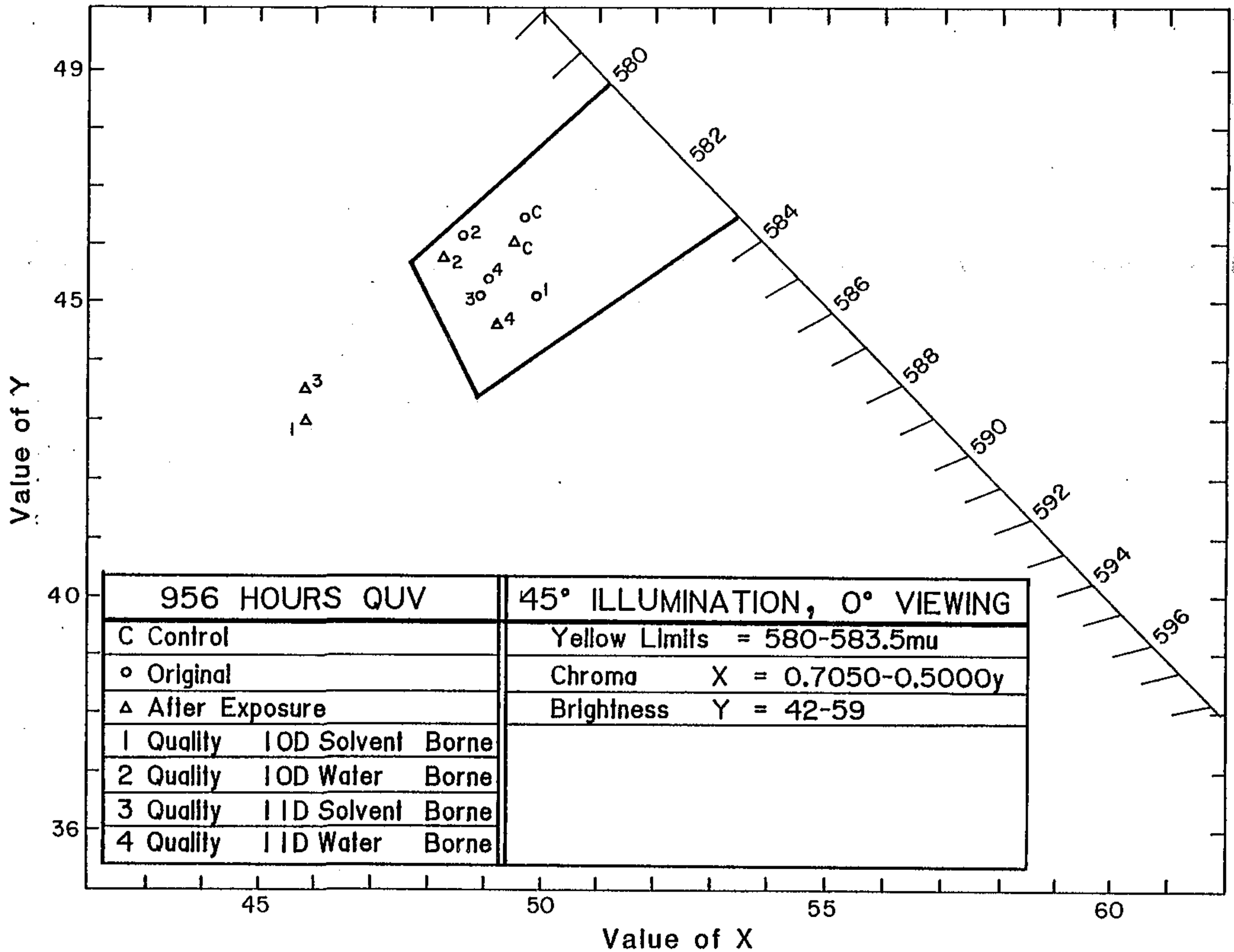


Figure 6 HUNTER COLOR DIFFERENCE METER

APPENDIX A

- SPECIFICATIONS -

STATE OF CALIFORNIA

Specification 8010-22L-22

Glass Spheres (Beads)

1.0 SCOPE

This specification covers glass spheres for use in providing nighttime retro-reflectance for painted traffic lines and other markings for highway delineation.

Type I is uncoated and Type II is coated to provide moisture proofing for high humidity conditions, where bead flow may be impaired.

2.0 APPLICABLE SPECIFICATIONS

The following specifications and test method in effect on the date of the Invitation for Bid forms a part of this specification where referenced.

American Society for Testing Materials (ASTM) D-153.

American Society for Testing Materials Special Publication 500.

California Test Method No. 202G, Appendix C.

American Association of State Highway and Transportation Officers, Designation M92.

California Specification 3990-XXX-01, Pallets, Wooden.

3.0 REQUIREMENTS

3.1 Glass spheres Type I and Type II shall meet the following requirements.

3.1.1 General

The glass spheres shall lend themselves readily to firm embedment in the traffic paint when dropped on a freshly placed paint line. The embedment shall be of such character as to provide a highly reflectorized surface on the paint with reserve reflectorizing capacity in the lower sections of the paint film: the reflection shall be effectively manifest to the operator of a motor vehicle when the headlights of the vehicle are shown on the marking.

3.1.2 Appearance

A minimum of 85% of the beads by count shall be colorless, true spheres, free of dark spots, milkiness, air inclusions and surface scratches when viewed under 20X magnification. The beads shall be clean and free from foreign matter in accordance with high grade commercial practice.

Cancels & Supersedes 8010-21K-22

3.1.3 Gradation

The glass spheres shall conform to the following grading requirements:

Sieve No.	Sieve Opening Inches	Percent By Weight Passing
30	0.0231	100
60	0.0098	40 - 70
80	0.0070	15 - 35
140	0.0041	0 - 5

3.1.4 Physical Properties

The glass spheres shall conform to the following properties:

Refractive Index, minimum	1.50
Specific Gravity	2.40 to 2.60
Moisture Content, maximum	0.01%

3.1.5 Chemical Stability

Refluxing a sample of beads for 8 hours with distilled water shall not produce more than a very slight reduction in luster or reflecting power of the beads.

3.1.6 Flow

Beads shall be free flowing. Fifty (50) pounds of the beads, emptied into a service box screen, U.S. Standard Sieve Size No. 16, shall pass completely through the screen without shaking or any excessive hand manipulation.

3.2 Type II (Moisture Proof):

The Type II beads shall conform to all the requirements for Type I beads and the following requirement for moisture resistance.

3.2.1 Moisture Resistance Test (Flow)

Moisture resistance of the beads shall be determined by the following procedure.

1. Use a pre-washed 10-1/2 x 17-1/2" unbleached cotton sheeting bag having a 48 x 48 thread count.

2. Turn the bag inside out to prevent water plus beads from being entrapped within the seams.

3. Place two pounds of beads in the cotton bag.

4. Immerse the bag containing the sample in a bucket of water at room temperature (70-72°F) for thirty seconds, or until the water covers the beads (whichever is longer).

5. Remove the bag and sample from water and squeeze the excess water out of the bag by twisting the neck of the bag.

6. Allow the bag to be suspended for two hours at room temperature. Do not allow the neck to loosen.

7. Mix the sample thoroughly by releasing the tension in the neck and shaking the bag, thus loosening the beads from bottom and sides.

8. Transfer the sample to the clean dry funnel (150 mm top diameter, 120 mm deep, 1/4 inch ID stem).

9. If the beads bridge in the funnel while pouring the sample in, the funnel can be tapped lightly at the beginning to start the flow but not after flow has once started.

10. After flow stops, the funnel must be essentially empty of glass spheres.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Inspection:

This material shall be inspected and tested as specified in the Invitation for Bid.

4.2 Testing:

4.2.1 Index of Refraction

The beads shall show a minimum index of refraction of 1.5 by the oil immersion method using a tungsten light, per ASTM Special Publication 500 Paragraph 1.3.2.1.

4.2.2 Specific Gravity

The beads shall have a specific gravity from 2.40 to 2.60 at 25°C, per ASTM D-153 Method A

4.2.3 Moisture Content

Moisture content, as determined by weight lost of 25 grams of beads in an oven at 105°C for three hours, shall not exceed 0.01 percent.

4.2.4 Chemical Stability

Refluxing of a 50 gram sample of beads in a Soxhlet extraction apparatus for 8 hours with distilled water shall not produce more than a very slight reduction in luster or reflecting power of the beads.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging:

Packaging may consist of either of the following two (2) containers.

(1) A 10 oz. burlap or Osnaburg bag approximately 14" x 25" in size with taped bottom and cemented center seams. Bags shall be lined with Kraft paper cemented to the fabric with a waterproof cement.

(2) A pinch bottom style paper bag having glued top and bottom seams. Interior construction shall consist of four (4) plies of 50 lb. extensible paper and one layer of polyethelene film of a minimum one and one-half (1-1/2) mill thickness sandwiched in between. The exterior ply shall be 60 lb. ribbed extensible paper with a slip resistant coating.

Each bag shall contain 50 pounds of glass spheres and shall be plainly and conspicuously marked or branded on the side with the net weight of the glass spheres. The open mouth shall be adequately shut by a method and in a manner acceptable to the State. The successful bidder may be required to submit a sample of the bag he proposed to use to the State for approval prior to use.

Packaging shall conform to the applicable rules and sections of the current National Motor Freight Classification in use at the time of delivery. Deviation from packaging requirements shall require written consent of the Office of Business Management of the Department of Transportation.

5.2 Marking:

Type I beads shall be marked with a wide blue diagonal stripe on the outside of the bag.

5.3 Shipping:

5.3.1 Pallets

The bags shall be palletized on pallets furnished by the vendor. The pallets shall become the property of the State of California. The pallets shall meet all the requirements of State Specification 3990-XXX-01, Type II, Size 2. The size shall be 42 inches by 42 inches.

The outside of one stringer shall be stenciled, "Return to Department of Transportation Warehouse".

5.3.2 Palletizing:

The bag shall be stacked 48 bags per pallet. The loaded pallets shall be plastic shrink wrapped.

6.0 NOTES

6.1 Patents:

The vendor shall agree to defend the State of California, all employees and officials thereof against any suit of law resulting from the design, device, material process or portion thereof, used in the manufacture or application of glass beads in traffic markings. The vendor shall further agree to indemnify and save harmless the Department of Transportation against any loss resulting from any suite for royalties, damange or costs.

DEPARTMENT OF GENERAL SERVICES
Office of Procurement
November 1982

STATE OF CALIFORNIA

Specification 8010-41G-21

Thermoplastic Traffic Striping Material, Hydrocarbon Binder, White and Yellow

1.0 SCOPE

This specification covers a reflectorized thermoplastic pavement striping material that is applied to portland cement or asphalt concrete road surfaces in a molten state by mechanical means. Upon cooling to normal pavement temperature this produces an adherent reflectorized stripe capable of resisting deformation by traffic.

2.0 APPLICABLE SPECIFICATIONS

The following specifications, test methods and standards in effect on the opening date of the Invitation for Bid form a part of this specification where referenced.

State of California Specification 8010-XXX-99, Inspection, Testing and Other Requirements for Protective Coatings.

California Test Method No. 423, latest revision.
California Test Method No. 660, latest revision.

California Department of Transportation, Standard Specification.

Federal Standard No. 595.

American Association of State Highway and Transportation Officials, AASHTO M427

American Society of Testing and Methods, ASTM E11, ASTM G53, ASTM D2784, ASTM E28, ASTM E97, ASTM E313.

3.0 REQUIREMENTS

3.1 Composition:

The thermoplastic material shall be 100 percent solids. The binder shall consist of synthetic hydrocarbon resins, and be homogeneously incorporated with all the necessary prime pigments, fillers and glass beads to produce a traffic coating to meet the requirements as specified herein.

3.2 Form:

The thermoplastic material shall be supplied in either block or granular form as required in the purchase request.

Cancels &
Supersedes
8010-31C-21

3.3 Application Type:

The thermoplastic material shall be formulated for application by extrusion or spray as required in the purchase request

3.4 Characteristics of the Finished Thermoplastic:

California Test Method 423 unless otherwise specified.

		White	Yellow
3.4.1	Glass Beads AASHTO M247 TYPE 1, percent by weight	25-30	25-30
3.4.2	Inert fillers, insoluble in hydrochloric acid, % pass, USA Standard Sieve No. 100, ASTM E11	100	100
3.4.3	Binder, percent by weight, minimum	18	18
3.4.4	Specify Gravity, maximum	2.15	2.15
3.4.5	Ring and Ball Softening Point ASTM E28	200-250	200-250
3.4.6	Tests on Material after 4 hours heat with stirring at 425°F ± 2°F, which includes 1 hour for meltdown and temperature stabilization.		
3.4.6.1	Tensile bond strength to an unprimed sand blasted portland cement concrete block, 0.125 inch thick film drawndown at 425°F, tested at 75° ± 2°F, psi, minimum	180	180
3.4.6.2	Brookfield Thermosel Viscosity, Spindle SC4-27, 20 RPM at 425°F, Poise		
	Extruded Type	45-100	45-100
	Spray Type, maximum	30	30
3.4.6.3	Impact Resistance, ASTM D2794, 0.125 inch thick film drawndown at 425°F on an unprimed sandblasted portland cement concrete block, male identor 5/8 inch, no female die. Test at 75 ± 2°F, inch-lbs, with no cracks or bond loss, minimum.	50	50
3.4.6.4	Daylight luminous Reflectance ASTM E97, minimum.	75	------

		White	Yellow
3.4.6.5	Color-yellow, shall match Fed 595, color No. 33538 and chromaticity limits shall lie within HUE = 580-583.5 nanometers, Chroma x = 0.7050-0.5000 y and brightness Y = 42-59 measured according to California test method Cal 660.	------	------
3.4.6.6	Yellowness Index, ASTM E313, calculated as YI = 100 (A-B)/G, maximum.	12	------
3.4.6.7	Ultra Violet Light and Condensate Exposure, ASTM G53. 300 hours total: alternate 4 hours UV exposure at 60°C; 4 hours condensate exposure at 40°C.		
	White - yellowness index, maximum	20	------
	Yellow - must meet chromaticity limits as specified in 3.4.6.5	------	Pass
3.4.6.8	Abrasion Test - 400 grs. glass beads, mesh-25+30, 22 psi air pressure, and cast sample 5 in. x 5 in. x 0.375 ins. Grams, loss, maximum	10	10
3.4.6.9	Hardness, Shore A-2 Durometer with 2 kilogram weight at 115°F	45-75	45-75

3.5 Other Requirements:

The thermoplastic material shall readily extrude or spray at temperatures between 400-450°F.

When applied to the pavement, the thermoplastic material shall be sufficiently tack-free to carry traffic in not more than 2 minutes when pavement surface temperature is at 50°F., and not more than 10 minutes when pavement surface temperature is 130°F.

3.6 Workmanship:

The pigment, beads, and fillers shall be well dispersed in the binder. The material shall be free from all skins, dirt, foreign objects, and other deleterious substances, and shall be of such composition that it will not bleed, stain, or discolor when applied to pavements.

Thermoplastic material shall not emit fumes which are toxic or injurious to persons or property when it is heated to application temperature. The material shall not emit excessive smoke during heating or application.

3.7 Shelf Life:

The material shall maintain the requirements of this specification for a minimum period of one year. Any materials failing to do so shall be replaced by the manufacturer at his expense.

3.8 Air Pollution Compliance:

This material shall comply with all applicable air pollution control rules and regulations.

3.9 Material Data Safety Sheets:

Material Data Safety Sheets shall be provided by the manufacturer to include Health Hazard information on the material when it is heated to application temperature.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Inspection:

This material shall be sampled and inspected in accordance with State of California Specification 8010-XXX-99, or as otherwise deemed necessary. State Specification 8010-XXX-99 is on file and obtainable at the Office of Procurement.

The minimum size batch of thermoplastic traffic striping material sampled and tested shall not be less than 2000 pounds unless the total order is less than this amount.

All thermoplastic material intended for use by the State of California must be sampled and approved by the Transportation Laboratory before shipment. Manufacturers within the State of California must contact the Berkeley or Los Angeles Inspection Office for sampling procedures.

Manufacturers outside the State of California must submit the following information before shipment.

1. State specification number
2. Color, white and yellow and tons of each
3. Form - block or granular
4. Type - extruded or spray
5. Exact address of shipment
6. Number and identification of batches comprising shipment
7. Date of manufacture
8. Purchase order or contract number

The above information is to be sent to, Transportation Laboratory, 5900 Folsom Boulevard, Sacramento, CA 95819. On delivery, the thermoplastic will be sampled for compliance to specification. Material not meeting the specification shall be removed and replaced by the manufacturer at his expense, including all costs for handling, testing and shipping.

4.2 Testing:

All tests shall be performed according to the specified test method, latest revision. Qualitative and quantitative analysis may also be performed by X-ray diffraction, X-ray emission, infrared and other instrumental methods of analysis, at the option of the Department of Transportation.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging:

5.1.1 Block Form:

The thermoplastic material shall be packaged in suitable containers to which it will not adhere nor interact with during shipment or storage. The blocks of cast thermoplastic material shall be approximately 35 x 12 x 2 inches and shall weigh approximately 50 pounds.

5.1.2 Granular Form:

The thermoplastic material shall be packaged in meltable bags which are compatible with the thermoplastic and shall weigh approximately 50 lbs. The containers must have sufficient strength and be properly sealed to prevent breakage and leakage during normal handling.

5.2 Marking:

Each container label shall include: State Specification Number, color, type of binder, spray type or extrusion type, manufacturer's name and address, date of manufacture, and batch number. All markings on containers shall be legible and permanent. Markings shall not smear or rub off container. Containers failing to meet marking requirements will not be accepted.

The containers and labeling shall meet all applicable U.S. Department of Transportation and Interstate Commerce Commission regulations. Concerning the contents, each container shall be labeled with such warnings or precautions as are required by local, state and Federal laws and regulations.

6.0 NOTES

6.1 Certificate of Compliance:

The manufacturer of thermoplastic materials shall furnish the Engineer with a Certificate of Compliance in conformance with the provisions of the Department of Transportation Standard Specifications, January 1984, Section 6-1.07, "Certificate of Compliance." The certificate shall also include a list, by title and section, of all applicable state and federal packaging and labeling laws and a statement that all requirements have been met.

Certificates of Compliance shall be sent to California Department of Transportation, 5900 Folsom Blvd., Sacramento, California 95819.

6.2 The Contractor shall assume all costs arising from the use of patented materials, equipment, devices or processes used on or incorporated in the work, agrees to indemnify and save harmless the State of California and its duly authorized representatives from all suits at law or action of every nature for or on account of the use of any patented materials, equipment, devices or processes.

DEPARTMENT OF GENERAL SERVICES
Office of Procurement
July 1984

State of California

SPECIFICATION

Water Base Traffic Line Paint
Rapid Dry
PTW1 White
PTW2 Yellow

1.0 SCOPE

This specification is intended to cover ready-mixed water-based traffic line paint to be hot applied to either asphaltic or portland cement concrete pavements.

2.0 APPLICABLE SPECIFICATIONS

The following specifications, test methods, and standards in effect on the date of the invitation for Bid form a part of this specification where referenced.

ASTM D562, ASTM D1475, ASTM D1210, MIL-P-28577A(YD), ASTM D2369, ASTM D711, ASTM D1640, TT-P-115E, Fed. Test Std. No. 141B, Method 6192, ASTM D2486, Fed. Color Std. 595 No. 33538, ASTM/ANSI G53, ASTM D211, ASTM D869, ASTM D2243, ASTM E70.

State of California Specification 8010-XXX-99 (except for shelf life), inspection, Testing and other requirements for Protective Coatings.

Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulations Board, Refernece 49CFR. ICC Regulations.

Title 8, Chapter 4 - Division of Industrial Safety orders State of California.

3.0 REQUIREMENTS

Paint must meet both General and Specific Requirements.

3.1 General:

This specification is intended to specify paint that will meet service requirements for highway construction and maintenance.

3.1.1 The composition of the paint vehicle shall be 100% Acrylic polymer, dispersed in water and containing the necessary co-solvents, dispersants, wetting agents, preservatives and all other additives, so that the paint shall retain its viscosity, stability and all other properties as specified herein.

3.1.2 Paint shall be free from foreign materials, such as dirt, sand, fibers from bags or other material capable of clogging screens, valves, pumps, and other equipment used in a paint striping apparatus.

3.1.3 The paint pigment shall be well ground and be properly dispersed in the vehicle. The pigment shall not cake or thicken in the container, and shall not become granular or curdled. Any settlement of pigment in the paint shall result in a thoroughly wetted, soft mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sidewise manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency. If the paint cannot be easily redispersed, due to excessive pigment settlement as described above, or due to any other cause, the paint shall be considered unfit for use.

3.1.4 The properties specified in (3.1.3) shall remain in effect for 6 months after acceptance and delivery. The vendor shall be held responsible for all costs and transportation charges incurred in replacing paint that is unfit for use. The properties of any replaced paint, as specified in (3.1.3) shall remain in effect for 6 months from date of acceptance and delivery.

3.1.5 The paint shall, in addition to meeting with specification requirements, comply with all air pollution control rules and regulations within the State of California in effect at the time the paint is manufactured.

3.2.0 Specific Requirements

		PTW1 White	PTW2 Yellow
3.2.1	Viscosity, KU at 77°F ± 1°F	75-90	75-90
3.2.2	Density, Lbs/Gal at 77°F ± 1°F	12.5-13.5	12.5-13.5
3.2.3	Fineness of Grind, HEGMAN, Minimum	3.0	3.0
3.2.4	Pigment, Weight %	50-57	50-57
3.2.5	Total Solids, Weight %	70-76	70-76
3.2.6	ASTM D711, Dry to No pick up without beads, Maximum, Minutes	8	8
3.2.7	Dry thru, maximum, minutes	18	18
3.2.8	Flexibility, 1/2 inch Mandrel	Pass	Pass
3.2.9	Static Heat Stability, 1 week at 120°F, Viscosity Increase, Maximum, KU	10	10
3.2.10	Dry Opacity, Minimum	0.90	0.90
3.2.11	Yellowness Index, Maximum	0.10	0.10
3.2.12	Reflectance, Minimum	85	58
3.2.13	Color	White	Federal 595, No.33538
3.2.14	Lightness Difference, ΔL, Maximum	-	6.0
3.2.15	Settling Test Rating, Minimum	7.0	7.0
3.2.16	Spray Application Test, Hot applied with heated airless spray unit	Pass	Pass
3.2.17	Volatile Organic Compounds, Grams per liter of paint minus water, Maximum	250	250
3.2.18	Freeze-Thaw	Pass	Pass
3.2.19	pH, Minimum	8.0	8.0
3.2.20	Abrasion Resistance, Wear Index, Maximum	225	225
3.2.21	Scrub Resistance, Cycles, Minimum	400	400

4.0 Test Methods for Specific Requirements

Specific Requirement	Test Method
3.2.1	ASTM D562
3.2.2	ASTM D1475
3.2.3	ASTM D1210
3.2.4	MIL-P-28577A (YD)
3.2.5	ASTM D2369, Except use water and dry for 1 hour at 110+ 2°C
3.2.6	ASTM D711, No beads
3.2.7	Test performed on same draw down as in (3.3.6). Test same as outlined in ASTM D1640, except that no thumb pressure is used. The time is noted when the thumb is turned thru an angle of 90° while in contact with the film, does not break the film.
3.2.8	TT-P-115E
3.2.9	Place 1 pint of test paint in sealed can and heat in an air circulation oven at 120+1°F for 1 week. Remove from oven and check viscosity in KU at 77+1°F. Observe any signs of instability.
3.2.10	On a black-white Leneta Chart, Form 2A Opacity, draw down film covering both black and white portions of chart. Use a 0.010 inch gap doctor blade. Dry for 24 hours at 77°F. Use a Photovolt Reflection Meter Model 670 with Search Unit provided with Tristimulus filters, green, blue and amber. Calibrate according to manufacturer's instructions and measure the reflectance over the white and black portions with the green filter. Dry Opacity is calculated as $\frac{\text{Reflectance over black.}}{\text{Reflectance over white.}}$

Specific Requirement	Test Method

3.2.11 Using the same draw down sample as in (3.2.10) measure the reflectance over the white part of chart using the green, blue and amber tristimulus filters. Calculate the Yellowness Index = $\frac{\text{Amber-Blue}}{\text{Green}}$

3.2.12 Using the same draw down sample as in (3.2.10) measure the reflectance over the white portion of the Leneta Chart using the green tristimulus filter.

3.2.13 Draw down 0.015 inch thick wet film and dry 24 hours at 77°F. The yellow shall match Federal Standard 595, No. 33538. The white shall have a reflectance as specified in 3.2.12.

3.2.14 ASTM/ANSI G53 - A 0.015 inch wet film thickness is drawn down on a suitable tinplate and trimmed to 3 in. by 6 in. and dried 3 days at 77°F. Measure reflectance using green tristimulus filter with a Photovolt Reflectance Meter, Model 670. Place sample in QUV apparatus on light-condensate mode (4x4) and temperature at 60°C for 168 hours. Remove and again measure reflectance. Calculate ΔL as outlined in ASTM D211.

3.2.15 This is an accelerated test procedure to screen paints with unsatisfactory anti-settle properties that would cause settlement problems in storage. The apparatus consists of a Model J-1A Jogger vibrating unit, enclosed in an insulated box, externally heated by thermostatically controlled heat gun. A 1-quart paint can filled to 1/2 inch from top with test paint with lid secured by can clips, is placed in the apparatus with vibration set to maximum and temperature controlled at 160°F±3°F. The sample is subjected to heat vibration for 24 hours, then removed and allowed to stand undisturbed at ambient temperature for 24 hours. Lid removed and paint rated on a scale of 0-10 according to ASTM D869.

3.2.16 Paint applied at 0.005 inches to 0.007 inches dry film thickness with the laboratory or operational kinetically heated airless striping units, shall show the following properties at ambient temperatures of 65° to 80°F and paint temperature of not over 155°F with 4 to 6 lbs. of post applied glass beads per gallon of paint. Beads shall conform to the current State Specifications.

1. Dry to a no track condition in 5 minutes or less when the line is crossed over in a passing maneuver with a standard size automobile.
2. Produce a clean cut, smooth line with no overspray or puddling.
3. Paint shall accept the glass beads so that the spheres shall be embedded into the paint film to a depth of 50% of their diameter.

Specific Requirement	Test Method

4. Paint, when heated to the temperature necessary to obtain the specified dry time, shall show no evidence of instability such as viscosity increase, gelling or poor spray application under operational conditions. Additionally, there shall be a 20°F range within which the paint will atomize properly and give a good line.

3.2.17 Use current ASTM or other adopted method in effect at time of paint manufacture to determine VOC level and water content of the paint.

3.2.18 ASTM D2243

3.2.19 ASTM E70

3.2.20 Federal Test Method Standard No. 141B, Method 6192. Use CS17 wheels and 1000 gram weights. Draw down paint to a 0.015 inch wet thickness. Dry for 3 days at 77°F. Run 2000 cycles and calculate Wear Index. Run 3 samples and report average of the 3 runs.

3.2.21 ASTM D2486. Use a 0.010 inch gap doctor blade. Dry film thickness must be from 0.003 inches to 0.004 inches. Cure 3 days at 77°F.

5.0. <u>Quality Assurance Provisions</u>

5.1 Sampling and Testing:

Unless otherwise permitted by the Maintenance Engineer, paint shall be sampled at the place of manufacture and application will not be permitted until the paint has been approved by the Maintenance Engineer.

Check samples of finished paint as being applied will be taken at intervals as determined by the Maintenance Engineer.

Infra red, x-ray, and other analytical methods in use by the Transportation Laboratory may be used.

6.0 <u>Preparation for Delivery</u>

6.1 Packaging:

All manufactured paint shall be prepared at the factory ready for application.

The finished paint shall be furnished in container size as specified in the purchase order or contract. When 5-gallon containers are specified, they shall be round and have lug-type crimp lids with ring seals and be equipped with ears.

The container base shall have a bail. If 55-gallon steel drums are specified, they must have removable lids and airtight band fasteners. All shipping containers must comply with the Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49 CFR. The containers and lids must be lined with a suitable coating so as to prevent attack by the paint or by agents in the air space above the paint. The lining must not come off the container or lid as skins.

All containers shall be colored <u>WHITE</u>, including lids.

All containers shall be properly sealed with suitable gaskets and shall show no evidence of leakage and shall remain in satisfactory condition for a period of 6 months after delivery. Vendor shall be held responsible for replacing containers unfit for use and will be held responsible for all costs and transportation charges incurred in replacing paint and containers.

6.2 Marking:

All containers of paint shall be labeled showing the exact title of the specification, State specification number, manufacturer's name, date of manufacture, State Lot Number, and manufacturer's batch number.

Precautions concerning the handling and the application of paint shall be shown on the label of the paint container in accordance with the Construction and General Industry Safety Orders of the Division of Industrial Safety, Department of Industrial Relations of the State of California.

All containers of paint shall be labeled to indicate that the contents fully comply with all rules and regulations concerning air pollution control in the State of California.

The manufacturer of the paint shall be responsible for proper shipping labels with reference to whether the contents are toxic, corrosive, flammable, etc., as outlined in Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49CFR.

7.0 NOTES

7.1 Patents:

The Contractor shall assume all costs arising from the use of patented materials, equipment, devices, or processes used on or incorporated in the work, and agrees to indemnify and save harmless the State of California, and its duly authorized representatives from all suits at law or action of every nature for, or on account of, the use of any patented materials, equipment, devices or processes.

State of California

SPECIFICATION

Water Base Traffic Line Paint
Regular Dry

PTW3 White
PTW4 Yellow

1.0 SCOPE

This specification is intended to cover ready mixed water based traffic line paint to be cold applied to either asphaltic or portland cement concrete pavements.

2.0 APPLICABLE SPECIFICATIONS

The following specifications, test methods, and standards in effect on the date of the invitation for Bid form a part of this specification where referenced.

ASTM D562, ASTM D1475, ASTM D1210, MIL-P-28577A(YD), ASTM D2369, ASTM D711, ASTM D1640, TT-P-115E, Fed. Test Std. No. 141B, Method 6192, ASTM D2486, Fed. Color Std. No. 595 No. 33538, ASTM/ANSI G53, ASTM D211, ASTM D869, ASTM D2243, ASTM E70.

State of California Specification 8010-XXX-99, Inspection, Testing and other requirements for Protective Coatings.

Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49 CFR.

Construction and General Industry Safety Orders of the Division of Industrial Safety, Department of Industrial Relations of the State of California.

3.0 REQUIREMENTS

Paint must meet both General and Specific Requirements

3.1 General:

This specification is intended to specify paint that will meet service requirements for highway construction and maintenance.

3.1.1 The composition of the paint vehicle shall be 100% Acrylic polymer, dispersed in water and containing the necessary co-solvents, dispersants, wetting agents, preservatives and all other additives, so that the paint shall retain its viscosity, stability and all other properties as specified herein.

3.1.2 Paint shall be free from foreign materials, such as dirt, sand, fibers from bags or other material capable of clogging screens, valves, pumps, and other equipment used in a paint striping apparatus.

3.1.3 The paint pigment shall be well ground and be properly dispersed in the vehicle. The pigment shall not cake or thicken in the container, and shall not become granular or curdled. Any settlement of pigment in the paint shall result in a thoroughly wetted, soft mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sidewise manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency. If the paint cannot be easily redispersed, due to excessive pigment settlement as described above, or due to any other cause, the paint shall be considered unfit for use.

3.1.4 The properties specified in (3.1.3) shall remain in effect for 6 months after acceptance and delivery. The vendor shall be held responsible for all costs and transportation charges incurred in replacing paint that is unfit for use. The properties of any replaced paint, as specified in (3.1.3) shall remain in effect for 6 months from date of acceptance and delivery.

3.1.5 The paint shall, in addition to meeting with specification requirements, comply with all air pollution control rules and regulations within the State of California in effect at the time the paint is manufactured.

3.2	Specific Requirements	PTW3 White	PTW4 Yellow
3.2.1	Viscosity, KU at 77°F ± 1°F	68-75	68-75
3.2.2	Density, Lbs/Gal at 77°F ± 1°F	12.0-13.5	12.0-13.5
3.2.3	Fineness of Grind, HEGMAN, Minimum	3.0	3.0
3.2.4	Pigment, Weight %	45-55	45-55
3.2.5	Total Solids, Weight %	67-75	67-75
3.2.6	ASTM D711, Dry to No Pick Up without Beads, maximum, minutes	15	15
3.2.7	Dry thru, maximum, minutes	30	30
3.2.8	Flexibility, 1/2 inch Mandrel.	Pass	Pass
3.2.9	Static Heat Stability, 1 week at 120°F Viscosity increase, maximum, KU	10	10
3.2.10	Abrasion Resistance, wear index, maximum	225	225
3.2.11	Scrub Resistance, Cycles, minimum	400	400
3.2.12	Dry Opacity, minimum	0.90	0.90
3.2.13	Yellowness Index, maximum	0.10	-
3.2.14	Reflectance, minimum	85	58
3.2.15	Color	White	Federal 595
3.2.16	Lightness Difference, ΔL, maximum	-	6.0
3.2.17	Settling Test Rating, minimum	7.0	7.0
3.2.18	Cold applied with air atomized non-heated unit	Pass	Pass
3.2.19	Volatile Organic Compounds, grams per liter of paint minus water, maximum	250	250
3.2.20	Freeze-Thaw, ASTM D2243	Pass	Pass
3.2.21	pH, Minimum	8.0	8.0

4.0 Test Methods for Specific Requirements

Specific Requirement	Test Method
3.2.1	ASTM D562
3.2.2	ASTM D1475
3.2.3	ASTM D1210
3.2.4	MIL-P-28577A (YD)
3.2.5	ASTM D2369, Except use water and dry for 1 hour at 110±2°C
3.2.6	ASTM D711, No beads
3.2.7	Test performed on same draw down as in (3.2.6). Test same as outlined in ASTM D1640, except that no thumb pressure is used. The time is noted when the thumb is turned thru an angle of 90° while in contact with the film, does not break the film.
3.2.8	TT-P-115E
3.2.9	Place 1 pint of test paint in sealed can and heat in an air circulation oven at 120± 1°F for 1 week. Remove from oven and check viscosity in KU at 77±1°F. Observe any signs of instability.
3.2.10	Federal Test Method Standard No. 141B, Method 6192. Use CS17 wheels and 1000 gram weights. Draw down paint to a 0.015 inch wet thickness. Dry for 3 days at 77°F. Run 2000 cycles and calculate wear index. Run 3 samples and report average of the 3 runs.
3.2.11	ASTM D2486. Use a 0.010 inch gap doctor blade. Dry film thickness must be from 0.003 inches to 0.004 inches. Cure 3 days at 77°F.
3.2.12	On a black-white Leneta Chart, Form 2A Opacity, draw down film covering both black and white portions of chart. Use a 0.010 inch gap doctor blade. Dry for 24 hours at 77°F. Use a Photovolt Reflection Meter Model 670 with Search Unit provided with Tristimulus filters, green, blue and amber. Calibrate according to manufacturer's instructions and measure the reflectance over the white and black portions with the green filter. Dry Opacity is calculated as $\frac{\text{Reflectance over black.}}{\text{Reflectance over white.}}$
3.2.13	Using same draw down sample as in (3.2.12) measure the reflectance over the white part of chart using the green, blue and amber tristimulus filters. Calculate the yellowness Index = $\frac{\text{Amber-Blue}}{\text{Green}}$

3.2.14 Using same draw down sample as in (3.2.12) measure the reflectance over the white portion of the Leneta Chart using the green tristimulus filter.

3.2.15 Draw down 0.015 inch thick wet film and dry 24 hours at 77°F. The yellow shall match Federal Standard 595, No. 33538. The white shall have a reflectance as specified in 3.2.14.

3.2.16 ASTM/ANSI G53 - A 0.015 inch wet film thickness is drawn down on a suitable tinplate and trimmed to 3 in. by 6 in. and dried 3 days at 77°F. Measure reflectance using green tristimulus filter with a Photovolt Reflectance Meter, Model 670. Place sample in QUV apparatus on light-condensate mode (4x4) and temperature at 60°C for 168 hours. Remove and again measure reflectance. Calculate ΔL as outlined in ASTM D211.

3.2.17 This is an accelerated test procedure to screen paints with unsatisfactory anti-settle properties that would cause settle problems in storage. The apparatus consists of a Model J-1A Jogger vibrating unit, enclosed in an insulated box, externally heated by a thermostatically controlled heat gun. A 1 quart paint can filled to 1/2 inch from top with test paint with lid secured by can clips, is placed in the apparatus with vibration set to maximum and temperature controlled at 160°F+3°F. The sample is subjected to heat vibration for 24 hours, then removed and allowed to stand undisturbed at ambient temperature for 24 hours. Lid removed and paint rated on a scale of 0-10 according to ASTM D869.

3.2.18 When applied with the Laboratory cold applied air atomized unit, the paint shall show the following properties at ambient temperatures from 50°F to 100°F and a dry paint thickness from 0.005 inches to 0.007 inches with a level of 4 to 6 lbs. glass beads per gallon of paint. Beads shall conform to the current State Specification

1. Dry to a no-track condition in 10 minutes or less when line is crossed over in a passing maneuver with a standard sized automobile.

2. Produce a clean cut, smooth line with minimal overspray and no puddling.

3. Paint shall accept glass beads so that the spheres shall be imbedded into the paint film to a depth of 50% of their diameter.

3.2.19 Use current ASTM or other adopted method in effect at time of paint manufacture to determine VOC level and water content of the paint.

3.2.20 ASTM D2243

3.2.21 ASTM E70

4.0 <u>Quality Assurance Provisions</u>

4.1 Sampling and Testing:

Unless otherwise permitted by the Maintenance Engineer, paint shall be sampled at the place of manufacture and application will not be permitted until the paint has been approved by the Maintenance Engineer.

An unopened container of each batch of finished paint shall be furnished to the Maintenance Engineer at the jobsite for testing. Check samples of finished paint as being applied will be taken at intervals as determined by the Maintenance Engineer.

5.0 <u>Preparation for Delivery</u>

5.1 Packaging:

All manufactured paint shall be prepared at the factory ready for application.

The finished paint shall be furnished in container size as specified in the purchase order or contract. When 5-gallon containers are specified, they shall be round and 24-gauge steel, minimum, and have lug-type crimp lids with ring seals and be equipped with ears. The container base shall have a bail. If 55-gallon steel drums are specified, they must have removable lids and airtight band fasteners. All shipping containers must comply with the Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49CFR. The containers and lids must be lined with a suitable coating so as to prevent attack by the paint or by agents in the air space above the paint. The lining must not come off the container or lid as skins.

All containers shall be colored <u>WHITE</u>, including lids.

All containers shall be properly sealed with suitable gaskets and shall show no evidence of leakage and shall remain in satisfactory condition for a period of 12 months after delivery. Vendor shall be held responsible for replacing containers unfit for use and will be held responsible for all costs and transportation charges incurred in replacing paint and containers.

5.2 Marking:

All containers of paint shall be labeled showing the exact title of the specification, State specification number, manufacturer's name, date of manufacture, State lot number, and manufacturer's batch number.

Precautions concerning the handling and the application of paint shall be shown on the label of the paint container in accordance with the Construction and General Industry Safety Orders of the Division of Industrial Safety, Department of Industrial Relations of the State of California.

All containers of paint shall be labeled to indicate that the contents fully comply with all rules and regulations concerning air pollution control in the State of California.

The manufacturer of the paint shall be responsible for proper shipping labels with reference to whether the contents are toxic, corrosive, flammable, etc., as outlined in Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49CFR.

6.0 NOTES

6.1 Patents:

The Contractor shall assume all costs arising from the use of patented materials, equipment, devices, or processes used on or incorporated in the work, and agrees to indemnify and save harmless the State of California, and its duly authorized representatives from all suits at law or action of every nature for, or on account of, the use of any patented materials, equipment, devices or processes.

STATE OF CALIFORNIA

Specification 8010-32F-30

Paint, Water-Borne Traffic Line, Rapid Dry, White and Yellow

1.0 SCOPE

This specification is intended to cover ready-mixed water-borne traffic line paint to be hot applied to either asphaltic or portland cement concrete pavements.

2.0 APPLICABLE SPECIFICATIONS

The following specifications, test methods, and standards in effect on the opening date of the Invitation for Bid form a part of this specification where referenced.

ASTM D562, ASTM D1475, ASTM D1210, ASTM D2369, ASTM D711, ASTM D1640, ASTM D2486, ASTM G53, ASTM D821, ASTM D2243, and ASTM E70.

Military Standard MIL-P-28577A(YD).

Federal Specification TT-P-1952B.

Highway Yellow Color Tolerance Chart PR Color #1, Federal Highway Administration.

State of California Specification 8010-XXX-99 (except for shelf life), Inspection, Testing and Other Requirements for Protective Coatings.

Department of Transportation, Standard Specifications, 1978 or 1981.

Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49CFR. ICC Regulations.

Title 8, Chapter 4 - Division of Industrial Safety Orders, State of California.

3.0 REQUIREMENTS

3.1 General:

This specification is intended to specify paint that will meet service requirements for highway construction and maintenance.

Cancels &
Supersedes
8010-31C-30

3.1.1 Pre-Bid Qualification

To qualify for a purchase order award, all vendors must submit samples of the paint to Caltrans Lab, 5900 Folsom Blvd., Sacramento, CA 95819. Paint submitted must meet the requirements of this specification before an award will be made.

3.1.2 A minimum of 5 gallons of each color shall be shipped along with at least 1 gallon of the recommended clean up and flushing solvent. The composition of the clean up and flushing solvent shall be clearly labeled on each can. All shipping and transportation charges shall be prepaid by the vendor.

3.1.3 All paint manufactured by the successful bidder must be the same as submitted for Pre-Bid Qualification and be within the tolerance limits as specified in the Requirements of this specification.

3.2 Composition:

3.2.1 The composition of the paint shall be determined by the manufacturer. It will be the manufacturer's responsibility to produce a pigmented water-borne paint containing all the necessary co-solvents, dispersants, wetting agents, preservatives and all other additives, so that the paint shall retain its viscosity, stability and all other properties as specified herein.

No pre-mix glass beads will be permitted in the finished paint.

3.3 Characteristics of the Finished Paint:

		White	Yellow
3.3.1	Viscosity, KU at $77^{o}F \pm 1^{o}F$, ASTM D562	68-90	68-90
3.3.2	Fineness of Grind, HEGMAN, minimum, ASTM D1210	3.0	3.0
3.3.3	Dry to No pick up without beads, minutes, maximum, ASTM D711	10	10
3.3.4	Dry thru, minutes, maximum	20	20

Test may be performed on same draw down sample as in (3.3.3). This test is the same as outlined in ASTM 1640, except that no thumb pressure is used. The thumb is turned thru an angle of 90^{o} while in contact with the film. The drying time at which this rotation does not break the film is recorded.

		White	Yellow
3.3.5	Volatile Organic Compounds, Grams per liter of paint, excluding water, maximum.	250	250

Use current ASTM or other adopted method in effect at time of paint manufacture to determine VOC level and water content of the paint.

3.3.6	Flexibility, TT-P-1952B	Pass	Pass
3.3.7	Static Heat Stability, 1 week at 120°F, Viscosity Increase, Maximum, KU	10	10

Place 1 pint of test paint in sealed can and heat in an air circulation oven at 120 ± 1°F for 1 week. Remove from oven and check viscosity in KU at 77 ± 1°F. Observe any signs of instability.

3.3.8	Heat-Shear Stability, Viscosity Increase, KU, maximum	15	15

One pint of the paint is sheared in a Waring Blender at high speed to 150°F. Blender should have tight fitting lid and taped to minimize solvent loss. When paint reaches 150°F, stop the Blender and immediately can and apply cover. Let cool overnight and examine for gelling or other signs of instability. Measure viscosity at 77 ± 1°F with Stormer Viscometer.

Run total solids on sheared paint and adjust solids by adding water to original solids content. Again check viscosity in KU.

3.3.9	Scrub Resistance, Cycles, minimum	400	400

ASTM D2486. Use an appropriate doctor blade to provide a dry film thickness of 3 to 4 mils. Cure 24 hrs. at 77°F +24 hrs at 120°F.

		White	Yellow
3.3.10	Dry Opacity, minimum	0.90	0.90

On a black-white Leneta Chart, Form 2A Opacity, draw down film covering both black and white portions of chart. Use a 10 mil gap doctor blade. Dry for 24 hours at 77°F. Use a Photovolt Reflection Meter Model 670 with Search Unit provided with Tristimulus filters, green, blue and amber. Calibrate according to manufacturer's instructions and measure the reflectance over the white and black portions with the green filter. Dry Opacity is calculated as:

$$\frac{\text{Reflectance over black}}{\text{Reflectance over white}} = \text{Dry Opacity}$$

3.3.11	Yellowness Index, maximum	0.10	---

Using the same draw down sample as in (3.3.10), measure the reflectance over the white part of chart using the green, blue and amber tristimulus filters. Calculate the Yellowness Index = $\frac{\text{Amber-Blue}}{\text{Green}}$.

3.3.12	Reflectance, minimum	85	58

Using same draw down sample as in (3.3.10), measure the reflectance over the white portion of the Leneta Chart using the green tristimulus filter.

3.3.13	Color	White	Yellow must fall within the color tolerance limits as shown on Highway Yellow Chart PR Color #1, Federal Highway Administration.

Draw down a 15 mil thick wet film and dry 24 hours at 77°F + 24 hrs. at 120°F. Compare color with PR Color #1. In borderline cases, determine C.I.E. data for source C and plot on chromaticity diagram to determine if yellow is within limits of PR Color #1.

3.3.14 Ultra Violet Color Stability - Yellow Paint

ASTM G53 - A 15 mil thick wet film is drawn down on an aluminum panel and trimmed to 3 in. by 6 in. and dried 24 hours at 77°F +24 hrs. at 120°F. Expose sample for a total time of 300 hrs. Determine C.I.E. data for source C and plot on chromaticity diagram. Color must still fall within the tolerance limits as shown on Yellow Chart PR Color #1, Federal Highway Administration.

		White	Yellow
3.3.15	Spray Application Test, Hot applied with heated airless spray unit	Pass	Pass

The paint shall be applied at 5 to 7 mils dry thickness with the laboratory or operational kinetically heated airless striping units. The paint shall show the following properties at ambient temperatures of 50° to 100°F with a paint spray temperature of 150°F, maximum, and 4 to 6 lbs. of post-applied glass beads per gallon of paint. Beads shall conform to the current State Specifications.

a. Dry to a no-track condition in 5 minutes or less when line is crossed over in a passing maneuver with a standard sized automobile.

b. Produce a clean cut, smooth line with no overspray or puddling.

c. Paint shall accept glass beads so that the spheres shall be imbedded into the paint film to a depth of 50% of their diameter.

d. Paint, when heated to the temperature necessary to obtain the specified dry time, shall show no evidence of instability such as viscosity increase, gelling or poor spray application under operational conditions.

3.3.16	Freeze-Thaw, ASTM D2243	Pass	Pass
3.3.17	Road Service Rating, minimum	7.0	7.0

The test stripes shall be applied transversely across the road, 4 inches in width and approximately 12 ft. long. Transportation Laboratory equipment and personnel will be used to apply the stripes.

An airless applicator with kinetic heater will be used, maximum heat of application to be 150°F.

Dry paint thickness of the test stripes shall be from 5 to 7 mils as determined from samples taken during application. For this determination, information is required from the manufacturer on the dry density of each paint submitted, in lbs/gal.

Current State Specification glass beads (water proof type) will be applied concurrently with the paint at a rate such that the initial bead retention on the test line is a minimum of 4 lbs. of beads per gallon of wet paint. The initial bead retention will be determined analytically in the Transportation Laboratory concurrently with the determination of the dry paint thickness. The paint shall accept the glass beads so that the spheres are imbedded into the paint film to a depth of 50% of their diameter. Test stripes will be observed for a period of 180 days from date of application. Paints will be evaluated for wear according to ASTM D821.

After 180 days of service, paints with a rating of No. 7 or better will be accepted. All ratings will be taken in the wheel track area. Glass beads shall show no more than a 30% loss after 180 days of test. This is determined by taking close-up photographs of the paint film and by count, determining the average bead loss.

The road service test may be waived at the option of the Engineer or evaluated for a period of less than 180 days. If evaluated for less than 180 days, the rating must be 7.0 minimum.

3.4 Allowable Variations:

The following properties will be measured at the time of qualification and again during delivery of production lots. These properties must remain within the allowable variations as indicated.

		White	Yellow
3.4.1	Density, Lbs/Gal at 77°F ± 1°F ASTM D1475, allowable variation from qualifying sample	± 0.3	± 0.3
3.4.2	Pigment, Weight %, MIL-P-28577A Allowable variation from qualifying sample	± 2.0	± 2.0
3.4.3	Total Solids, Weight %, ASTM D2369, Procedure B. Allowable variation from qualifying sample.	± 1.5	± 1.5
3.4.4	Vehicle Infrared Spectra, allowable variation from qualifying sample	None	None
3.4.5	X-Ray Diffraction Analysis of Pigment, allowable variation from qualifying sample	None	None
3.4.6	pH, ASTM E70 allowable variation from qualifying sample	± 1.0	± 1.0

3.5 Workmanship:

3.5.1 Paint shall be free from foreign materials, such as dirt, sand, fibers from bags or other material capable of clogging screens, valves, pumps, and other equipment used in a paint striping apparatus.

3.5.2 The paint pigment shall be well ground and be properly dispersed in the vehicle. The pigment shall not cake or thicken in the container, and shall not become granular or curdled. Any settlement of pigment in the paint shall result in a thoroughly wetted, soft pass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sidewise manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency. If the paint cannot be easily redispersed, due to excessive pigment settlement as described above, or due to any other cause, the paint shall be considered unfit for use.

3.5.3 The paint shall retain all specified properties under normal storage conditions for 8 months after acceptance and delivery. The vendor shall be responsible for all costs and transportation charges incurred in replacing paint that is unfit for use. The properties of any replacement paint, as specified in (3.3), shall remain satisfactory for 8 months from date of acceptance and delivery.

3.5.4 The paint shall comply with all air pollution control rules and regulations within the State of California in effect at the time the paint is manufactured.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Inspection:

This material shall be inspected and tested in accordance with State of California Specification 8010-XXX-99, or as otherwise deemed necessary.

4.2 Sampling and Testing:

Unless otherwise permitted by the Engineer, paint shall be sampled at the place of manufacture and application will not be permitted until the paint has been approved by the Engineer.

Check samples of finished paint while being applied will be taken at intervals as determined by the Engineer.

Infrared, x-ray, and other analytical methods in use by the Transportation Laboratory may be used.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging:

All manufactured paint shall be prepared at the factory ready for application.

The finished paint shall be furnished in container size as specified in the purchase order or contract. When 5-gallon containers are specified, they shall be round and have lug-type crimp lids with ring seals and be equipped with ears and a bail.

If 55-gallon steel drums are specified, they must have removable lids and airtight band fasteners. All shipping containers must comply with the Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49 CFR. The containers and lids must be lined with a suitable coating so as to prevent attack by the paint or by agents in the air space above the paint. The lining must not come off the container or lid as skins.

All containers shall be colored WHITE, including lids.

All containers shall be properly sealed with suitable gaskets and shall show no evidence of leakage and shall remain in satisfactory condition for a period of 12 months after delivery. Vendor shall be held responsible for replacing containers unfit for use and will be responsible for all costs and transportation charges incurred in replacing paint and containers.

5.2 Marking:

All containers of paint shall be labeled showing the state specification number, manufacturer's name, date of manufacture, State lot number, and manufacturer's batch number. Containers shall be clearly labeled Rapid Dry Water-Borne Traffic Paint.

Precautions concerning the handling and the application of paint shall be shown on the label in accordance with the Construction and General Industry Safety Orders of the Division of Industrial Safety, Department of Industrial Relations of the State of California.

All containers of paint shall be labeled to indicate that the contents fully comply with all rules and regulations concerning air pollution control in the State of California.

The manufacturer of the paint shall be responsible for proper shipping labels with reference to whether the contents are toxic, corrosive, flammable, etc., as outlined in Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49CFR.

6.0 NOTES

6.1 Patents:

The Contractor shall assume all costs arising from the use of patented materials, equipment, devices, or processes used on or incorporated in the work, and agrees to indemnify and save harmless the State of California, and its duly authorized representatives from all suits at law or action of every nature for, or on account of, the use of any patented materials, equipment, devices or processes.

6.2 Certification of Compliance:

The manufacturer shall furnish a Certificate of Compliance with each batch of paint, in accordance with the provisions of Section 6-1.07 of Department of Transportation Standard Specifications, January 1978 or 1981.

DEPARTMENT OF GENERAL SERVICES
Office of Procurement
June 1983

STATE OF CALIFORNIA

Specification 8010-42L-30

Paint, Water-Borne Traffic Line, Rapid Dry, White, Yellow and Black

1.0 SCOPE

This specification is intended to cover ready-mixed one component water-borne traffic line paint to be applied to either asphaltic or portland cement concrete pavements.

2.0 APPLICABLE SPECIFICATIONS

The following specifications, test methods, and standards in effect on the opening date of the Invitation for Bid form a part of this specification where referenced.

ASTM D562, ASTM D1475, ASTM D1210, ASTM D2369, ASTM D711, ASTM D1640, ASTM D2486, ASTM G53, ASTM D821, ASTM D2243, ASTM E70, ASTM D93, and ASTM D3723.

California Test Method No. 660.

Federal Specification TT-P-1952B.

Federal Specification 595a, Color 33538 and 37038.

State of California Specification 8010-XXX-99 (except for shelf life), Inspection, Testing and Other Requirements for Protective Coatings.

Department of Transportation, Standard Specifications, 1984.

Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49CFR. ICC Regulations.

3.0 REQUIREMENTS

3.1 General:

This specification is intended to specify paint that will meet service requirements for highway construction and maintenance.

Cancels &
Supersedes
8010-41K-30 &
8010-31F-33

3.1.1 Pre-Bid Qualification

To qualify for a purchase order award, all vendors must submit samples of the paint to Caltrans Lab, 5900 Folsom Blvd., Sacramento, CA 95819. Paint submitted must meet the requirements of this specification before an award will be made. Vendor must qualify for white, yellow and black paints, no partial qualification will be allowed.

3.1.2 A minimum of four (4) gallons each of white and yellow and one (1) gallon of black is required. If clean up and flushing solvent is other than water, the recommend solvent shall be printed on the label. All shipping and transportation charges shall be prepaid by the vendor.

3.1.3 All paint manufactured by the successful bidder must be the same as submitted for Pre-Bid Qualification and be within the tolerance limits as specified in the Requirements of this specification.

3.2 Composition:

3.2.1 The composition of the paint shall be determined by the manufacturer. It will be the manufacturer's responsibility to produce a pigmented water-borne paint containing all the necessary co-solvents, dispersants, wetting agents, preservatives and all other additives, so that the paint shall retain its viscosity, stability and all other properties as specified herein.

No pre-mix glass beads will be permitted in the finished paint.

3.3 Characteristics of the Finished Paint:

		White	Yellow	Black
3.3.1	Viscosity, KU at 77°F ± 1°F, ASTM D562	70-85	70-85	70-85
3.3.2	Fineness of Grind, HEGMAN, minimum, ASTM D1210	3.0	3.0	3.0
3.3.3	Dry to No pick up without beads, minutes, maximum, ASTM D711	10	10	10
3.3.4	Dry thru, minutes, maximum	20	20	20

Test may be performed on same draw down sample as in (3.3.3). This test is the same as outlined in ASTM 1640, except that no thumb pressure is used. The thumb is turned thru an angle of 90° while in contact with the film. The drying time at which this rotation does not break the film is recorded.

		White	Yellow	Black
3.3.5	Volatile Organic Compounds, Grams per liter of paint, excluding water, maximum.	250	250	250

Use current ASTM or other adopted method in effect at time of paint manufacture to determine VOC level and water content of the paint.

3.3.6	Flash Point, ASTM D93, Method A, ^{o}F, minimum	100	100	100
3.3.7	Flexibility, TT-P-1952B	Pass	Pass	Pass
3.3.8	Static Heat Stability, 1 week at 120^{o}F, Viscosity, KU	68-90	68-90	68-90

Place 1 pint of test paint in sealed can and heat in an air circulation oven at 120 $\pm$ 1^{o}F for 1 week. Remove from oven and check viscosity in KU at 77 $\pm$ 1^{o}F. Observe any signs of instability.

3.3.9	Heat-Shear Stability, Viscosity, KU	68-95	68-95	68-95

One pint of the paint is sheared in a Waring Blender at high speed to 150^{o}F. Blender should have tight fitting lid and taped to minimize volatile loss. When paint reaches 150^{o}F, stop the Blender and immediately can and apply cover. Let cool overnight and examine for gelling or other signs of instability. Measure viscosity at 77 $\pm$ 1^{o}F with Stormer Viscometer.

Run total solids on sheared paint and adjust solids by adding water to original solids content. Again check viscosity in KU.

3.3.10	Scrub Resistance, Cycles, minimum	800	800	-----

ASTM D2486. Use an appropriate doctor blade to provide a dry film thickness of 3 to 4 mils. Cure 24 hrs. at 77^{o}F $\pm$ 2^{o}F and 40-55% relative humidity.

		White	Yellow	Black
3.3.11	Dry Opacity, minimum	0.90	0.90	-----

On a black-white Leneta Chart, Form 2C Opacity, draw down film covering both black and white portions of chart. Use a 10 mil gap doctor blade. Dry for 24 hours at 77^{o}F. Use a Photovolt Reflection Meter Model 670 with Search Unit provided with Tristimulus filters, green, blue and amber. Calibrate according to manufacturer's instructions and measure the reflectance over the white and black portions with the green filter. Dry Opacity is calculated as:

$$\frac{\text{Reflectance over black}}{\text{Reflectance over white}} = \text{Dry Opacity}$$

		White	Yellow	Black
3.3.12	Yellowness Index, maximum	10	-----	-----

Proceed as described in 3.3.11, only use a 15 mil gap doctor blade. Measure the reflectance of the paint film, using the green, blue and amber tristimulus filters. Calculate the Yellowness

$$\text{Index} = \frac{\text{Amber-Blue}}{\text{Green}} \times 100$$

		White	Yellow	Black
3.3.13	Reflectance, minimum	85	-----	-----

With same draw down sample as in (3.3.12), measure the reflectance of the paint film, using the green tristimulus filter.

3.3.14 Yellow Color - shall match Federal 595a, Color 33538, and chromacity limits shall lie within HUE,580-583.5 nanometers, CHROMA, x = 0.7050-0.5000y and BRIGHTNESS, Y = 42-59, when measured acccording to California Test Method No. 660.

3.3.15 Black Color - shall match Federal 595a, Color 37038.

3.3.16 Ultra Violet Light and Condensate Exposure, ASTM G53. 300 hours total: alternate 4 hours UV exposure at 60°C; 4 hours condensate exposure at 40°C.

	White	Yellow	Black
White - yellowness index, maximum	12	-----	-----
Yellow - must meet chromaticity limits as specified in 3.3.14			

		White	Yellow	Black
3.3.17	Spray Application Test.	Pass	Pass	-----

The paint shall be applied at 5 to 7 mils dry thickness with the laboratory heated striping unit. The paint shall show the following properties at ambient temperatures of 50° to 100°F with a paint spray temperature of 150°F, maximum, and 4 to 6 lbs. of post-applied glass beads per gallon of paint. Beads shall conform to the current State Specifications.

a. Dry to a no-track condition in 5 minutes or less when line is crossed over in a passing maneuver with a standard sized automobile.

b. Produce a clean cut, smooth line with no overspray or puddling.

c. Paint shall accept glass beads so that the spheres shall be imbedded into the paint film to a depth of 50% of their diameter.

d. Paint, when heated to the temperature necessary to obtain the specified dry time, shall show no evidence of instability such as viscosity increase, gelling or poor spray application.

		White	Yellow	Black
3.3.18	Freeze-Thaw, ASTM D2243	Pass	Pass	Pass
3.3.19	Road Service Rating, minimum	7.0	7.0	-----

The test stripes shall be applied transversely across the road, 4 inches in width and approximately 12 ft. long. Transportation Laboratory equipment and personnel will be used to apply the stripes.

Dry paint thickness of the test stripes shall be from 5 to 7 mils as determined from samples taken during application. For this determination, information is required from the manufacturer on the dry density of each paint submitted, in lbs/gal.

Current State Specification glass beads (water proof type) will be applied concurrently with the paint at a rate such that the initial bead retention on the test line is a minimum of 4 lbs. of beads per gallon of wet paint. The initial bead retention will be determined analytically in the Transportation Laboratory concurrently with the determination of the dry paint thickness. The paint shall accept the glass beads so that the spheres are imbedded into the paint film to a depth of 50% of their diameter. Test stripes will be observed for a period of 180 days from date of application. Paints will be evaluated for wear according to ASTM D821.

After 180 days of service, paints with a rating of No. 7 or better will be accepted. All ratings will be taken in the wheel track area. Glass beads shall show no more than a 30% loss after 180 days of test. This is determined by taking close-up photographs of the paint film and by count, determining the average bead loss.

The road service test may be waived at the option of the Engineer or evaluated for a period of less than 180 days. If evaluated for less than 180 days, the rating must be 7.0 minimum.

3.4 Allowable Variations:

The following properties will be measured at the time of qualification and again during delivery of production lots. These properties must remain within the allowable variations as indicated.

		White	Yellow	Black
3.4.1	Density, Lbs/Gal at 77°F ± 1°F ASTM D1475, allowable variation from qualifying sample	± 0.3	± 0.3	± 0.3
3.4.2	Pigment, Weight %, ASTM D3723 Allowable variation from qualifying sample	± 2.0	± 2.0	± 2.5
3.4.3	Total Solids, Weight %, ASTM D2369, Procedure B. Allowable variation from qualifying sample.	± 2.0	± 2.0	± 2.5
3.4.4	Vehicle Infrared Spectra, allowable variation from qualifying sample	None	None	None
3.4.5	X-Ray Diffraction Analysis of Pigment, allowable variation from qualifying sample	None	None	None
3.4.6	pH, ASTM E70 allowable variation from qualifying sample	± 1.0	± 1.0	± 1.0

3.5 Workmanship:

3.5.1 Paint shall be free from foreign materials, such as dirt, sand, fibers from bags or other material capable of clogging screens, valves, pumps, and other equipment used in a paint striping apparatus.

3.5.2 The paint pigment shall be well ground and be properly dispersed in the vehicle. The pigment shall not cake or thicken in the container, and shall not become granular or curdled. Any settlement of pigment in the paint shall result in a thoroughly wetted, soft mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sidewise manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency. If the paint cannot be easily redispersed, due to excessive pigment settlement as described above, or due to any other cause, the paint shall be considered unfit for use.

3.5.3 The paint shall retain all specified properties under normal storage conditions for 8 months after acceptance and delivery. The vendor shall be responsible for all costs and transportation charges incurred in replacing paint that is unfit for use. The properties of any replacement paint, as specified in (3.3), shall remain satisfactory for 8 months from date of acceptance and delivery.

3.5.4 The paint shall comply with all air pollution control rules and regulations within the State of California in effect at the time the paint is manufactured.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Inspection:

This material shall be inspected and tested in accordance with State of California Specification 8010-XXX-99, or as otherwise deemed necessary. State Specification 8010-XXX-99 is on file and obtainable at the Office of Procurment.

All traffic paints intended for use by the State of California must be sampled and approved by the Transportation Laboratory.

Manufacturers within the State of California must contact the Berkeley or Los Angeles Caltrans Inspection Office for sampling procedures.

Manufacturers outside the State of California must submit the following information before shipment.

1. State specification number.
2. Color and number of gallons.
3. Exact address of shipment
4. Number and identification of batches comprising shipment.
5. Date of manufacture.
6. Purchase order or contract number.

The above information is to be sent to, Transportation Laboratory, 5900 Folsom Boulevard, Sacramento, CA 95819. On delivery, the paint will be sampled for compliance to specification. Material not meeting the specification shall be removed and replaced by the manufacturer at his expense, including all costs for handling, re-testing and shipping.

4.2 Sampling and Testing:

Unless otherwise permitted by the Engineer, paint shall be sampled at the place of manufacture and application will not be permitted until the paint has been approved by the Engineer.

Check samples of finished paint while being applied will be taken at intervals as determined by the Engineer.

Infrared, x-ray, and other analytical methods in use by the Transportation Laboratory may be used.

5.0 PREPARATION FOR DELIVERY

5.1 Packaging:

All manufactured paint shall be prepared at the factory ready for application.

The finished paint shall be furnished in container size as specified in the purchase order or contract. When 5-gallon containers are specified, they shall be round and have standard full open head and bail.

If 55-gallon steel drums are specified, they must have removable lids and airtight band fasteners. All shipping containers must comply with the Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49 CFR. The containers and lids must be lined with a suitable coating so as to prevent attack by the paint or by agents in the air space above the paint. The lining must not come off the container or lid as skins.

All containers shall be colored WHITE, including lids.

All containers shall be properly sealed with suitable gaskets and shall show no evidence of leakage and shall remain in satisfactory condition for a period of 12 months after delivery. Vendor shall be held responsible for replacing containers unfit for use and will be responsible for all costs and transportation charges incurred in replacing paint and containers.

All containers shall be palletized and banded for shipment.

5.2 Marking:

All containers of paint shall be labeled showing the state specification number, manufacturer's name, date of manufacture, color and manufacturer's batch number. Containers shall be clearly labeled Rapid Dry Water-Borne Traffic Paint.

All containers of paint shall be labeled to indicate that the contents fully comply with all rules and regulations concerning air pollution control in the State of California.

The manufacturer of the paint shall be responsible for proper shipping labels with reference to whether the contents are toxic, corrosive, flammable, etc., as outlined in Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49CFR.

6.0 NOTES

6.1 Patents:

The Contractor shall assume all costs arising from the use of patented materials, equipment, devices, or processes used on or incorporated in the work, and agrees to indemnify and save harmless the State of California, and its duly authorized representatives from all suits at law or action of every nature for, or on account of, the use of any patented materials, equipment, devices or processes.

6.2 Certification of Compliance:

The manufacturer shall furnish a Certificate of Compliance with each batch of paint, in accordance with the provisions of Section 6-1.07 of Department of Transportation Standard Specifications, 1984.

DEPARTMENT OF GENERAL SERVICES
Office of Procurement
November 1984

STATE OF CALIFORNIA

Specification 8010-31J-05

Paint, Solvent Borne, Traffic Line, Fast Dry, Yellow

1.0 SCOPE

This specification is intended to cover ready mixed traffic line paint to be applied to either asphaltic or portland cement concrete pavements.

2.0 APPLICABLE SPECIFICATIONS

The following specifications, test methods, and standards in effect on the date of the Invitation for Bid form a part of this specification where referenced.

American Society for Testing and Materials (ASTM) D-711, D-211, D-281, D-600, D-36, D-154, D-555, D-664, D-939, D-1298, and D-1616-60.

Federal Specifications TT-N-95 and TT-M-00261.

Federal Test Method Standard No. 141.

Federal Standard 595.

State of California Specification 8010-XXX-99, Inspection, Testing and Other Requirements for Protective Coatings.

Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49CFR.

Construction and General Industry Safety Orders of the Division of Industrial Safety, Department of Industrial Relations, of the State of California.

3.0 REQUIREMENTS

3.1 General:

This specification is intended to specify paint that will meet service requirements for highway construction and maintenance.

Paint shall be free from foreign materials, such as dirt, sand, fibers from bags or other material capable of clogging screens, valves, pumps, or other equipment used in a paint striping apparatus.

Cancels &
Supersedes
8010-21E-05

The paint pigment shall be well ground and be properly dispersed in the vehicle. The pigment shall not cake or thicken in the container, and shall not become granular or curdled. Any settlement of pigment in the paint shall result in a thoroughly wetted, soft mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sidewise manual motion of the paddle across the bottom of the container, to form a smooth uniform product of the proper consistency.

The properties described above shall remain for 12 months after delivery and acceptance by the Maintenance Engineer. The vendor will be held responsible for all costs and transportation charges incurred in replacing paint that is unfit for use.

Manufacturing Note:

Note #1 The specified amounts and materials used in each formula for achieving satisfactory pigment wetting and suspension may be varied to suit the vendor's method of manufacturing.

Note #2 Paint made with any variation per Note 1 shall still be required to conform to all requirements for the finished paint and all other requirements of this specification.

3.2 Materials:

The raw materials for use in the paint formula shall conform to the specifications designated by Federal serial number or paint material code number hereinafter specified. Subsequent amendments to the specifications quoted shall apply to all raw materials and finished products.

The paint shall, in addition to complying with specification requirements, comply with all air pollution control rules and regulations within the State of California in effect at the time the paint is manufactured.

3.3 Characteristics:

3.3.1

Composition	Specifications	Parts by Weight
Alkyd Acrylic Copolymer, 50% solids	(1)**	100
Poly Alpha Methylstyrene	(2)	100
Chlorinated Paraffin	(3)	50
Methyl Ethyl Ketone	TT-M-00261	155

Composition	Specifications	Parts by Weight
Aliphatic Thinner	(4)	80
Toluene Substitute	(5)	60
6% Cobalt Naphthenate	ASTM D-600 Class B	0.4
24% Lead Naphthenate	ASTM D-600 Class B	1.0
*Soya Lecithin		10
*Anti-settling Agent	(6)	6
*95% Methanol		2
Medium Chrome Yellow	ASTM D-211, Type III	75
Synthetic Hydrated Calcium Silicate	(7)	35
Magnesium Silicate	(8)	120
Calcium Carbonate	(9)	375

* See Manufacturing Note (Section 3.1)
**Numbers reference Raw Materials Specification (Section 3.3.3)

3.3.2 Characteristics of the Finished Paint

Viscosity, K.U. at 77°F	68-75
Weight per Gallon, lbs. at 77°F	11.4-11.7
Nonvolatile, Percent by Weight	68.0-71.0
Pigment, Percent by Weight	50-53
Fineness of Grind, Hegman, Minimum	3
Dry Time, ASTM D-711, without Beads, Minutes	4-7
Chlorine, Percent in Nonvolatile Vehicle	8-12
Color, Approximate	Federal Standard 595, No. 33538
$PbCrO_4$, %wt in pigment	10-13
45° Directional Reflectance, 0.010-inch Doctor Blade Gap, Green Filter, Minimum	62

The vehicle, when drawn down on a clean glass plate with a 0.010 inch gap Doctor blade, shall produce, within 15 minutes at 77°F, a clear, non-tacky, non-opaque, compatible film.

X-ray diffraction analysis of the pigment, infrared absorption curve of the vacuum dried vehicle solids, and the gas chromatograph analysis of the solvent system, each shall be in agreement as to positions of peaks and relative intensities when compared to the respective curves made from a Caltrans Laboratory prepared sample of the paint.

3.3.3 Raw Materials Specification

(1) Alkyd Acrylic Copolymer

Nonvolatile, %wt.	49-51
lbs. per gallon, nonvolatile average	9.42
% oil in nonvolatile, minimum	27
Type of oil	Oxidizing
% Phthalic Anhydride in nonvolatile, minimum	15
% Monomer in nonvolatile, minimum	45
Volatile Composition	
Paraffins and Naphthenes, % typical	20
Toluene and/or Ethylbenzene, % maximum	12
Other aromatics, C8 or above, % maximum	8
Exempt oxygenated, % typical	60
lbs. per gallon, solution, average	8.30
Viscosity, Gardner-Holdt	V-X
Color, Gardner 1963, maximum	5
Acid number, solution basis, maximum	7
Mineral spirits tolerance, %	30
Rosin and/or derivatives	None
Phenolic resin modifiers	None
(only present known source - Reichhold #13-645)	

(2) Poly Alpha Methylstyrene

Softening Point, °F, ASTM D-36	280-300
Viscosity, Gardner-Holdt, 60 Wt% in Toluene, ASTM D154, minimum	X
Color, Fed 141B, Method 451.1, maximum	2
Volatiles, Wt%, maximum	2.5
Appearance	Bright & clear
Iodine No. Wijs, ASTM D555	Nil
Acid No. ASTM D664	Nil
Saponification No. ASTM D939	Nil
Ash, % ASTM D555	0.001
Specific Gravity 60/60, ASTM D1298	1.075
Molecular Weight, 60°F	960
Refractive Index, 20°C	1.61
(only present known source - Amoco #18-290)	

(3) Chlorinated Paraffin

Chlorine, Percent by Weight	40-43
Color, Gardner	12 Maximum
Viscosity at 25°C, Poise	20-30
Specific Gravity at 25/25°C	1.150-1.170
Stability Maximum Percent of HCl Liberated in 4 Hours at 175°C	0.80

(4) Aliphatic Thinner

Color, Saybolt	+30
Specific Gravity at 60°F	0.7430-0.7540
Flash Point, TCC °F	22-32
Doctor Test	Negative
Corrosion Test ASTM D-1616-60	OK
Aniline Point	106-120
Kauri-Butanol Value, CCS	38-44
Aromatic Content (Toluene), Percent by Volume	9 Maximum
Refractive Index at 20°C	1.4136-1.4180

Distillation:

Percent Distilled	Temperature, °F
Initial Boiling Point	195-205
50%	206-216
Dry Point	235-265

(5) Toluene Substitute

Color, Saybolt	+30
Gravity, API, 60°F	32.6-33.0
Pounds per Gallon, 60°F	7.16 - 7.18
Flash Point, TCC, °F	40-44
Kauri Butanol Value	99-101
Total Aromatics, Volume, %	91-95.3

Distillation:	Temperature, °F
Initial Boiling Point	220-226
50% Recovered	226-228
90% Recovered	228-229
Dry Point	230-233

(6) Anti-Settling Agent

Organic derivative of a special magnesium montmorillonite clay:

Color	Cream white
Form	Finely divided powder
Specific Gravity	1.80
Fineness	Less than 5% retained on U.S. Standard Sieve No. 200

(7) Synthetic Hydrated Calcium Silicate

Oil Absorption, lbs./100 lbs., Gardner-Coleman Method	355-375
Water Absorption, Percent	380-420
pH	9.7-9.9
Bulking Value, Gals./lb.	0.0532
Color	White
Refractive Index	1.50-1.60
Moisture, Percent	5-7
Average, 325 Mesh Residue, Percent	2

(8) Magnesium Silicate

Specific Gravity	2.68-2.86
Oil Absorption, ASTM D-281	26-33
pH	8.9-9.6
Hegman Rating	3-5
Maximum Particle Size, Microns	55
Particle Shape	Platey
% Passing U.S. 325 Screen, Minimum	99
Dry Brightness, Minimum	93

(9) Calcium Carbonate

Oil Absorption, Spatula	18
Hegman Fineness	5
Surface area, square centimeters/gram	10,500

Particle Size Distribution:

Micron Diameter	% by Weight Below Indicated Size
30	100
15	95
10	85
5	49
1	15
Dry brightness, %	97
Bulking value, Gals./lb.	0.0443
Hardness, Moh scale	3.0
Particle shape	Rhombohedron

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Sampling and Testing:

Unless otherwise permitted by the Maintenance Engineer, paint shall be sampled at the place of manufacture and application will not be permitted until the paint has been approved by the Maintenance Engineer. Raw materials and copies of batch records used in the manufacture of the paint shall be submitted at intervals as determined by the Maintenance Engineer.

An unopened container of each batch of finished paint shall be furnished to the Maintenance Engineer at the jobsite for testing. Check samples of finished paint as being applied will be taken at intervals as determined by the Maintenance Engineer.

All tests will be conducted in accordance with the latest test methods of the American Society for Testing and Materials, Federal Test Method Standard No. 141, and methods in use by the Transportation Laboratory of the Division of Structures and Engineering Services, California Department of Transportation (Caltrans).

5.0 PREPARATION FOR DELIVERY

5.1 Packaging:

All manufactured paint shall be prepared at the factory ready for application.

The finished paint shall be furnished in container size as specified in the purchase order or contract. When 5-gallon containers are specified, they shall be round and 24-gauge steel, minimum, and have lug-type crimp lids with ring seals and be equipped with ears. The container base shall have a bail. If 55-gallon steel drums are specified, they must have removable lids and airtight band fasteners. All shipping containers must comply with the Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulations Board, Reference 49CFR. The containers and lids must be lined with a suitable coating so as to prevent attack by the paint or by agents in the air space above the paint. The lining must not come off the container or lid as skins.

All containers shall be colored black, including lids.

All containers shall be properly sealed with suitable gaskets and shall show no evidence of leakage and shall remain in satisfactory condition for a period of 12 months after delivery. Vendor will be held responsible for replacing containers unfit for use and will be held responsible for all costs and transportation charges incurred in replacing paint and containers.

All containers shall be palletized and banded for shipment.

5.2 Marking:

All containers of paint shall be labeled showing the exact title of the specification, State specification number, color, manufacturer's name, date of manufacture, and manufacturer's batch number.

Precautions concerning the handling and the application of paint shall be shown on the label of the paint container in accordance with the Construction and General Industry Safety Orders of the Division of Industrial Safety, Department of Industrial Relations, of the State of California.

6.0 NOTES

6.1 Patents:

The Contractor shall assume all costs arising from the use of patented materials, equipment, devices, or processes used on or incorporated in the work, and agrees to indemnify and save harmless the State of California, and its duly authorized representatives from all suits at law or action of every nature for, or on account of, the use of any patented materials, equipment, devices, or processes.

6.2 Certificate of Compliance:

The manufacturer shall furnish a Certificate of Compliance with each batch of paint, in accordance with the provision of Section 6-1.07 of Department of Transportation Standard Specifications, January 1981.

DEPARTMENT OF GENERAL SERVICES
Office of Procurement
September 1983

APPENDIX B

THERMOPLASTIC TEST METHODS

DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
Office of Transportation Laboratory
P.O. Box 19128
Sacramento, California 95819

California Test 423
April 1985

METHOD FOR TESTING THERMOPLASTIC TRAFFIC LINE MATERIAL

SCOPE

This test method is divided into the following parts:

1. Sample preparation for granular type with meltable bag and premelted block form material
2. Melting procedure
3. Binder content
4. Glass bead content and grading
5. Specific gravity
6. Ring and ball softening point
7. Tensile bond strength
8. Viscosity
9. Impact resistance
10. Yellow color in yellow thermoplastic
11. Yellowness index and daylight luminous reflectance in white thermoplastic
12. Hardness
13. Ultraviolet light and condensate exposure
14. Abrasion test

PART 1—SAMPLE PREPARATION

a. Sample preparation, granular type with meltable bag.

Apparatus

1) Scale, 100 lb capacity, capable of weighing to 0.10 lb.
2) Top loading balance, at least 200 gram capacity, capable of weighing to 0.01 gram.
3) Sample splitter with 2 inch wide slots and top hopper to hold a 50 lb bag of thermoplastic.

Procedure

1) Determine weight of bag plus thermoplastic.
2) Empty contents of bag into splitter box, mix and break up any large lumps.
3) Weigh the empty bag.
4) Split the sample with the splitter to yield a 6000 gram sample of the granular thermoplastic.
5) Calculate the weight of bag material to be added to the granular thermoplastic using the following ratio:

$$\frac{\text{Wt Bag + Thermoplastic (grams)}}{\text{Wt bag (grams)}} = \frac{\text{Wt Sample (grams)}}{\times \text{ (grams)}}$$

where × = weight of bag material to be added to granular thermoplastic sample.

6) Weigh out the calculated amount of bag material and cut up in small pieces and mix into the previously weighed sample of granular thermoplastic.
7) In the yellow thermoplastic, the lead chromate may be packaged separately in a sealed plastic bag within the original 50 lb bag. Remove the lead chromate bag and determine the net weight of the lead chromate. Calculate the amount of lead chromate to be added to the thermoplastic using the following ratio:

$$\frac{\text{Wt Bag+Thermoplastic (grams)}}{\text{Net Wt Lead Chromate (grams)}} = \frac{\text{Wt Thermoplastic Sample (grams)}}{\times \text{ (grams)}}$$

where × = weight of lead chromate to be added to the thermoplastic sample.

The sample is now ready for test.

b. Sample preparation, granular type with paper bag or nonmeltable plastic bag.

Empty contents of bag into splitter box, mix and split as outlined in (a) and prepare a 6000 gram sample with no bag.

c. Sample preparation, block type.

Break up plastic block in small pieces to yield a sample of 6000 grams.

PART 2—MELTING PROCEDURE

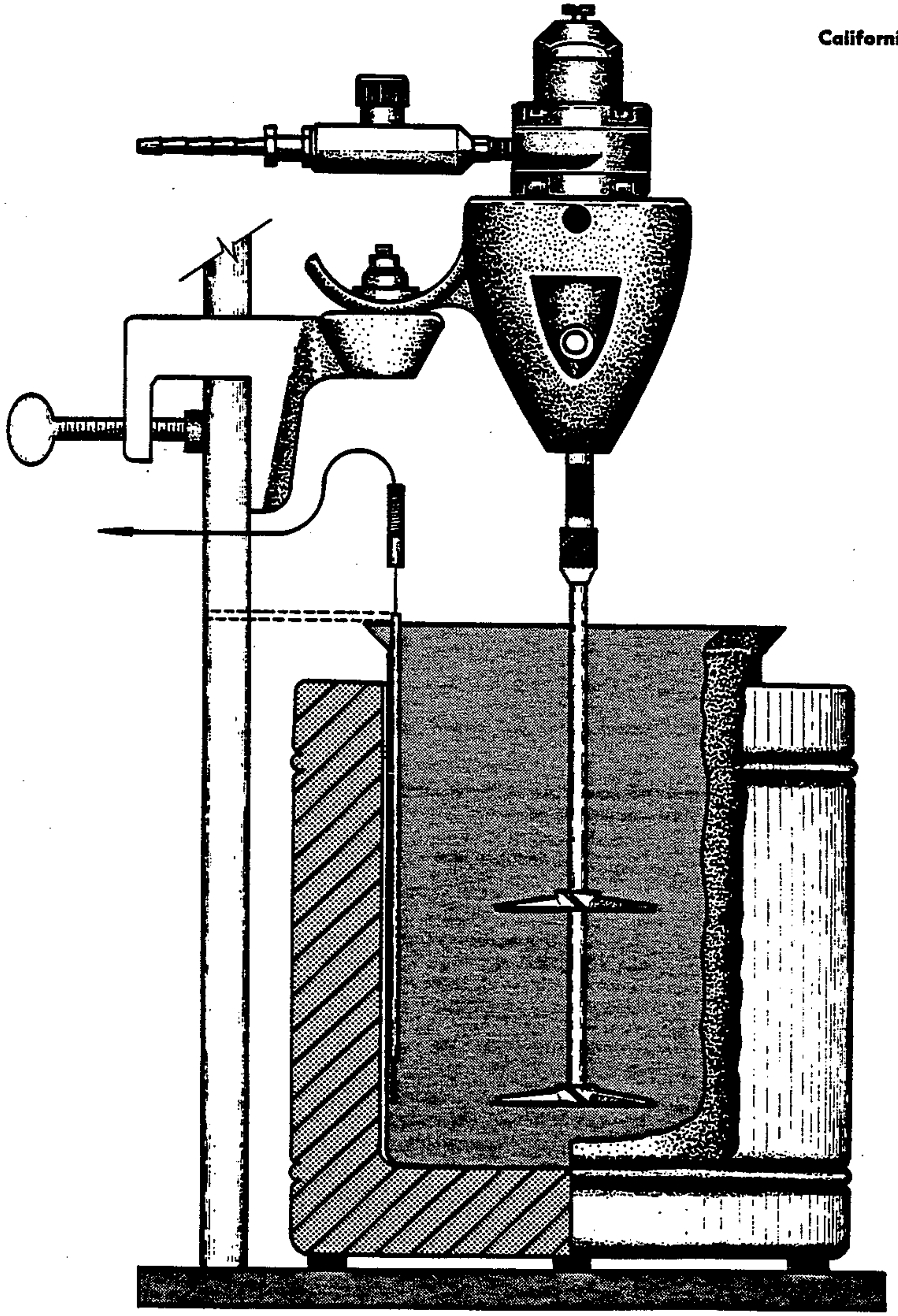
Apparatus

1) Stainless steel 4000 ml beaker, 6 inch diameter by 9 inches high, Vollrath No. 84000 or equivalent.
2) Glas-Col heating mantle, Model TM620 or equivalent.
3) Temperature indicator-controller, Omega Engineering Model 4001JF or equivalent.
4) Thermocouple, iron constantan, Omega Engineering No. TJ36-ICSS-116G-12 with 1/16 inch 304SS sheath or equivalent.
5) Air powered variable speed mixer, Lightnin Model 30 with 2 Lightnin A310 stainless steel impellers.

6) Aluminum lid to cover top of stainless steel 4000 ml beaker with slot to clear the air motor agitator shaft and thermocouple.
7) Stainless steel ladles with pouring spout, 1 oz. and 2 oz. capacity.
8) Tachometer to measure shaft speed of mixer.
9) Copper or SS tubing approximately ⅛ inch I.D. and 10 inches long.

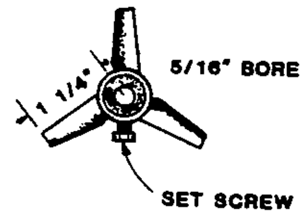
Procedure

1) Set up apparatus as shown in Figure 1. Wire the Glas-Col mantle power cord to the temperature indicator-controller according to manufacturers instructions. Mount the controller-indicator in a panel which can be wall mounted to keep the unit away from heat, dirt and vibration. When unit is ready for operation, make a test melt in order to set the proportional band and other adjustments to give a controlled temperature of 425°F ± 2°F.
2) Charge about ½ of prepared 6000 gram sample to the Vollrath stainless steel beaker and place beaker into Glas-Col mantle and attach the stirring shaft and thermocouple. Turn on power to the TM 620 mantle and controller. Note time of startup. As the thermoplastic melts down, add the remainder of the 6000 gram sample. Start the variable speed air agitator when plastic has softened sufficiently to mix. Continue mixing and heating until the temperature of the melt reaches 425°F ± 2°F and the melt is homogeneous. This should take about one hour from start-up.
3) At this time, using the 2 oz. stainless steel ladle, remove enough of the hot melt to fill a gallon paint can lid. This sample is allowed to cool and will be used for the glass bead and binder tests. At this point, samples are also cast for the ring and ball and specific gravity tests.

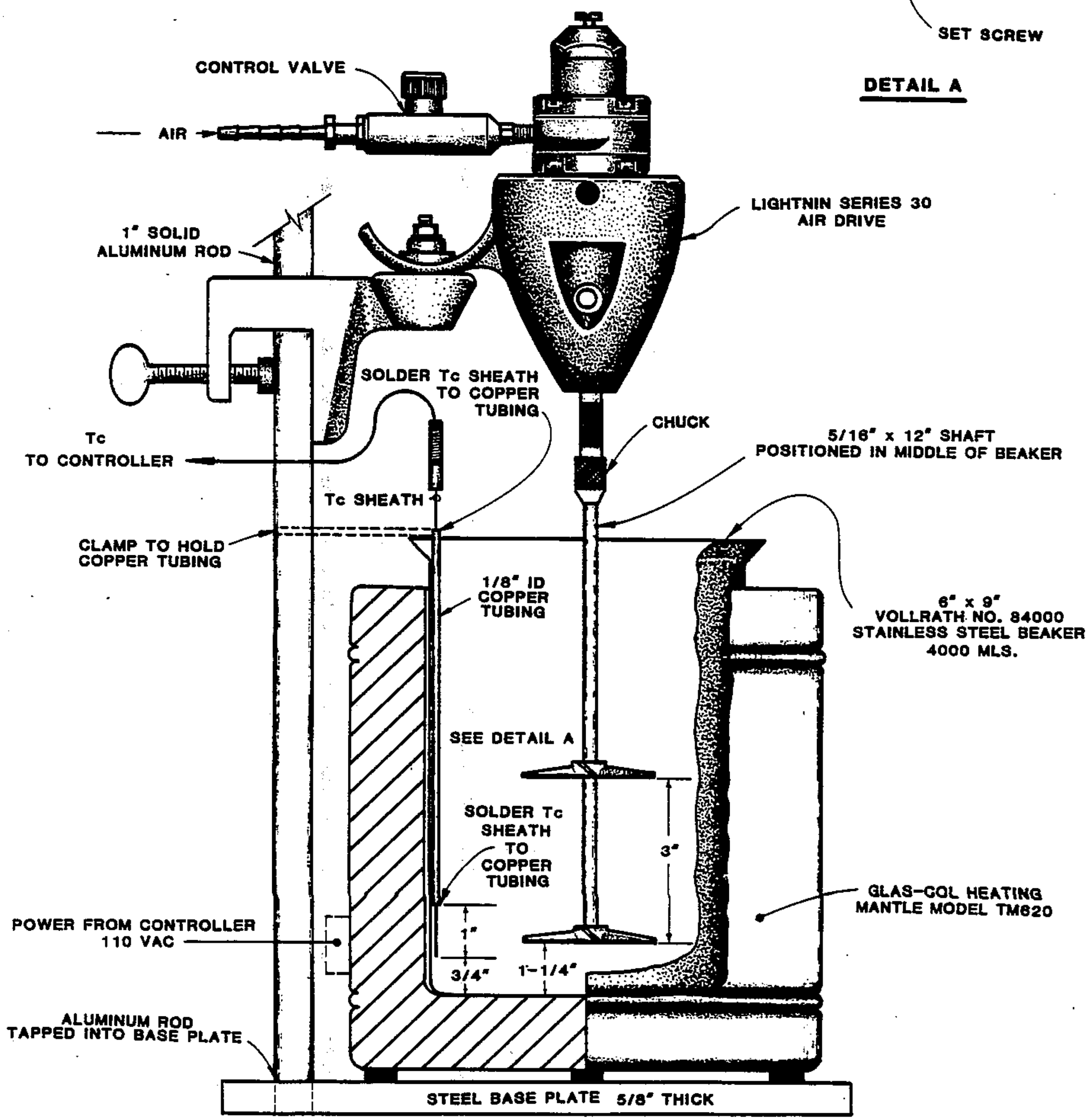


THERMO PLASTIC MELTER APPARATUS

Figure 1



DETAIL A



ASSEMBLY

Figure 1A

4) Set the RPM of the mixer shaft at 800 RPM with a suitable tachometer. Continue stirring and heating at 425°F ± 2°F for a total time of 4 hours from start of meltdown or as otherwise stated in specification. Keep aluminum cover over Vollrath beaker during the extended heating period.
5) At the end of the extended heating period, samples for bond, viscosity, impact, reflectance, color, UV exposure, abrasion and hardness are taken. The samples are taken while stirring and heating. After samples are taken, turn off agitator and power to Glas-Col and controller, remove Vollrath beaker from Glas-Col mantle and pour out hot melt into suitable cardboard box or other container for discard. Scrape out Vollrath beaker with a spatula while still hot—CAUTION—wear gloves. When cool, clean the residue in the Vollrath breaker with toluene or other suitable solvent.

PART 3—BINDER CONTENT

Apparatus

1) Porcelain crucible, 40 ml capacity
2) Diagonal cutter
3) Analytical balance
4) Desiccator
5) Muffle furnace capable of maintaining 900°F

Procedure

1) With diagonal cutters, cut the cooled sample on the can lid from initial meltdown into small pieces.
2) Weigh the porcelain crucible and fill with about 20 grams of thermoplastic.
3) Determine exact weight of thermoplastic and crucible.
4) Place the crucible in the muffle furnace and set controls for 900°F. Heat for 3 hours, remove crucible, cool in desiccator and weigh crucible.
5) Calculation

$$\% \text{ Binder} = \frac{A-B}{A-C} \times 100$$

A = Weight of crucible and thermoplastic
B = Weight of crucible and ash
C = Weight of crucible

6) Save the crucible and ash for the glass bead determination.

PART 4—GLASS BEAD CONTENT AND GRADING

Apparatus

1) Beakers, 600 and 400 ml capacity
2) Hot plate—stirrer
3) Teflon coated stirring bar
4) Toluene and acetone or other suitable solvents
5) Air circulation oven at 100°C
6) Balance, at least 200 gram capacity
7) Concentrated hydrochloric acid—reagent grade
8) U.S. 100 mesh screen
9) Diagonal cutters

Procedure

a. For glass bead content only—no grading analysis
   1) Weigh the 400 ml beaker to 0.01 gram.
   2) Place the crucible and ash from the binder determination into the bottom of beaker.
   3) Add concentrated HCl until effervescence ceases.
   4) Wash out crucible into the beaker and remove clean crucible.
   5) Dilute with hot water to 300 ml, let settle for about 15 minutes.
   6) Carefully decant all insoluble material making sure beads remain on the bottom of the beaker.
   7) Wash and decant about 3 or 4 more times or until only beads remain in the beaker and supernatant liquid is clear.
   8) Wash beads once with acetone, let settle, decant. After acetone has evaporated, place beaker in 100°C oven until dry.
   9) Remove from oven, cool and determine weight of beads in the 400 ml beaker.
   10) Calculation

$$\frac{\text{Weight of Beads}}{A-C} \times 100 = \% \text{ Beads}$$

For A and C, refer to Part 3, Binder Content, Item 5.

   11) Examine beads under 20× power microscope, if acid insoluble material other than beads is present, screen all the bead sample on a 100 mesh screen. If the insoluble material is larger than 100 mesh, then sample is failed. If the insolubles pass through the 100 mesh screen, then collect and weigh. Subtract the weight of the insolubles from the glass bead weight and correct the percentage of glass beads reported.

b. For glass bead grading analysis
   1) With diagonal cutters, cut the cooled sample on the can lid from initial meltdown into small

pieces.

2) Weigh the 600 ml beaker and fill with about 100 grams of the thermoplastic sample.
3) Determine the exact weight of the thermoplastic.
4) Add about 400 mls of toluene or other suitable solvent and place stirring bar in beaker.
5) Heat and stir for 1 hour—do not boil the toluene, keep temperature about 150°F by adjusting the hot plate control.
6) Remove beaker from hot plate, let settle for about 15 minutes, then decant the insolubles.
7) Repeat the solvent extraction, settle and decant operations.
8) Wash and decant residue 2 times with about 200 mls of acetone.
9) Add about 100 mls water and with stirring, carefully add concentrated HCl to the residue until all reaction has ceased. Remove stirring bar.
10) Dilute to about 500 mls with hot water, let settle 15 minutes and carefully decant insolubles making sure beads remain in the bottom.
11) Repeat the water dilution, settle and decant operations until supernatant liquid is clear.
12) Wash beads with about 200 mls acetone, settle and decant. After acetone has evaporated, dry the beaker in 100°C oven. Cool and weigh.
13) Calculation

$$\frac{\text{Weight of Beads}}{\text{Weight of Sample}} \times 100 = \%\ \text{Beads}$$

14) Examine the beads under microscope as done in Part a-11 and separate insolubles if necessary.
15) Run sieve analysis on the beads using appropriate sieves, depending on the requirements of the thermoplastic specification. Report percent pass through each sieve.

PART 5—SPECIFIC GRAVITY

Apparatus

1) Vacuum oven capable of maintaining 140°F and 30 inches of Hg.
2) Analytical balance
3) Glass beaker, 600 ml capacity
4) Metal stand for beaker to clear weighing pan
5) Aluminum disposable weighing dish, 63 mm wide and 17.5 mm deep. Fisher Scientific, Catalogue Number 8-732-5C or equal
6) Fine wire about 6 inches long

Procedure

1) From the initial meltdown, cast a sample about ⅛ inch deep from the Vollrath beaker into the bottom of the Fisher aluminum dish.
2) Immediately place dish in vacuum oven and start vacuum pump.
3) Sample should rise under vacuum. Control the air bleed valve to keep sample from overflowing dish.
4) Continue adjusting air bleed and when vacuum reaches about 30 inches of Hg and puffing has subsided, stop vacuum pump and remove dish from oven.
5) When cool, strip off aluminum, trim sides to remove uneven edges. Bore a small hole near one edge of the sample to accommodate the fine wire.
6) Weigh the sample in air.
7) Place beaker stand over balance pan and make sure it does not touch balance pan.
8) Position the 600 ml beaker full of distilled water on the beaker stand so that it does not touch the balance arms.
9) Suspend the sample by the fine wire and attach other end of wire to the top of the balance. Sample should not touch sides of beaker and should be completely immersed in the water.
10) Record the sample weight in the water.

Calculation

$$\text{Specific Gravity} = \frac{A}{A-W}$$

Where A = Weight in air
W = Weight in water

PART 6—RING AND BALL SOFTENING POINT

Apparatus

1) ASTM E28, Ring and Ball apparatus

Procedure

1) From the initial meltdown, cast a sample into the Ring and Ball ring, allow to cool and run the test according to ASTM E28.

Note: Tests on Parts 7 through 14 are done at the termination of the 4 hour heating and stirring period.

PART 7—TENSILE BOND STRENGTH

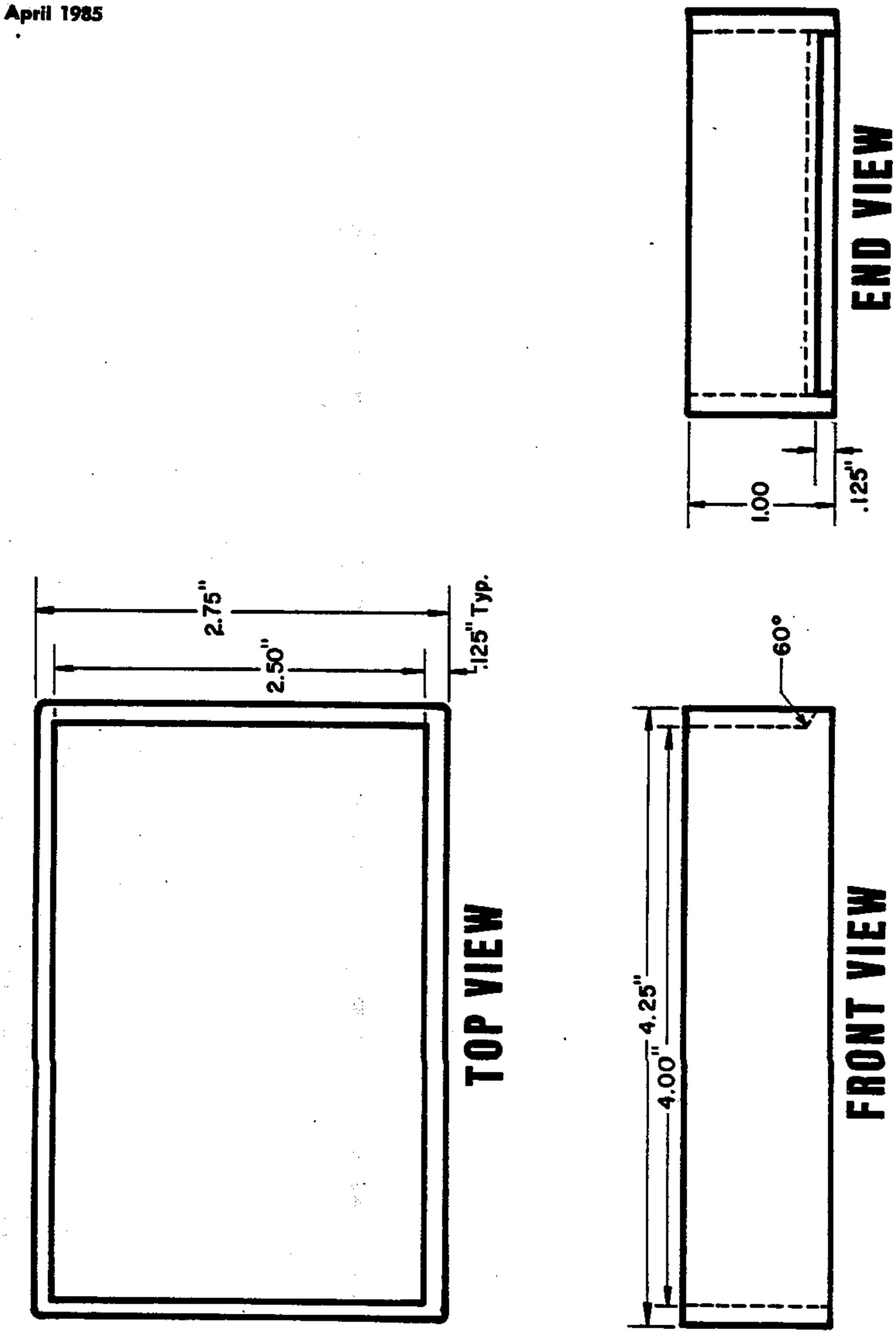
Apparatus

1) Concrete bricks 7×3½×2 inches, made from the following formula:

17.4 lbs portland cement
7.8 lbs free water
37.4 lbs aggregate, saturated surface dry
37.4 lbs sand, saturated surface dry

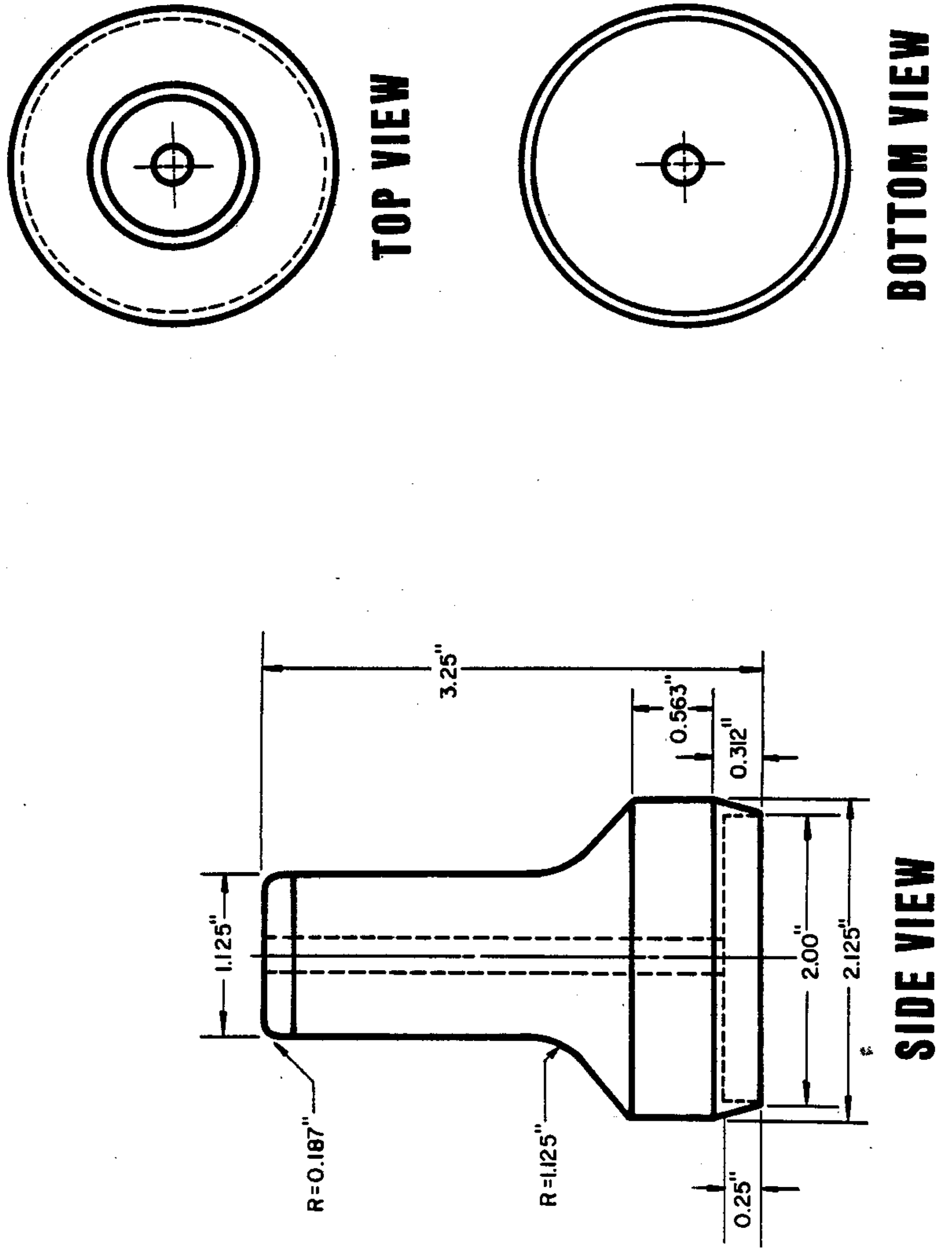
Use commercial quality PCC aggregate ⅜ inch maximum size.

2) Steel screed box with 0.125 inch opening as shown in Figure 2.
3) Steel die for cutting 2 inch diameter sample as shown in Figure 3.
4) Steel blade spatula with wooden handle and about 3 inch wide blade.
5) Round solid aluminum bar, 2 inch diameter and 1-¾ inches high. Bar is drilled and tapped to receive hook for connection to dynamometer or testing press. Bonding surface is sandblasted before use.



SCREED BOX

Figure 2



2" DIE

Figure 3

6) Suitable testing machine or dynamometer to pull the thermoplastic sample in tension at 5000 lb/min load rate.
7) Oven capable of maintaining 425°F ±2°F.

Procedure

1) Condition the screed box in the 425°F oven about ½ hour before test.
2) Sandblast the 7 × 3-½ inch face of a concrete brick.
3) Remove the screed box from oven and place on one end of the concrete brick.
4) With the 2 oz stainless steel ladle, remove a sample from the hot melt and quickly pour into the screed box and draw down a 0.125 inch film lengthwise down the middle of the brick.
5) Immediately place the 2 inch die in the middle of the thermoplastic film and hold firmly with one hand while scraping off the hot plastic with the steel spatula from the surface of the brick. Be sure to remove all plastic cleanly from the edges of the die.
6) Bond the 2 inch aluminum bar to the surface of the 2 inch diameter patty with epoxy adhesive. Be careful not to get the epoxy on the concrete brick. Wipe off any excess adhesive.
7) Let the epoxy cure overnight.
8) Using a suitable holding jig, thread a bar and hook into the threaded aluminum bar and pull in tension with a testing machine or dynamometer at load rate of 5000 lbs/minute. Record the load in pounds at break.

Calculation

$$\text{Tensile Bond Strength, psi} = \frac{\text{Load in Lbs}}{3.14}$$

PART 8—VISCOSITY

Apparatus

1) Brookfield digital viscometer, Model RVTD
2) Brookfield Thermosel and Model 64 temperature controller and accessories
3) Stainless steel SC4-27 spindle
4) Horizontal strip chart recorder, Linear 1200, Model 1202
5) Oven maintained at 425°F ±2°

Procedure

1) One-half hour before test, turn on Thermosel unit, set temperature at 425°F. Place SC4-27 spindle and stainless steel sample chamber in 425°F ±2° oven.
2) Check Thermosel for correct temperature, remove SC4-27 spindle from oven and attach to coupling link on the viscometer.
3) Remove sample chamber from oven and place in sample holder.
4) With the small 1 oz stainless ladle, sample the hot melt from the Vollrath beaker and carefully fill the sample chamber to ½ volume.
5) With the extracting tool, position the sample chamber in the Thermosel well and carefully rotate the chamber until it drops and locks into place.
6) Lower the spindle into the sample chamber and make alignments according to manufacturer's instructions.
7) Place insulating cap on sample chamber, turn on viscometer at 20 rpm, turn on strip recorder.
8) Initial readings are always high. When digital readout has stabilized, note reading and convert readout to poise. The linear recorder makes a permanent record of the viscosity. The recorder readily shows the point where viscosity readout has stabilized. If a recorder is not used, then the digital readout must be watched until stable.

Viscosity Calculation

For the SC4-27 spindle

Viscosity, poise = Scale Reading × 1.25 at 20 rpm

9) Raise the viscometer, cover the well with a lid to prevent hot plastic from dripping into Thermosel well. Remove and clean spindle.
10) Using the extracting tool, remove sample chamber from Thermosel well and pour out hot plastic. Soak the sample chamber in toluene or other suitable solvent and clean with a brush.

PART 9—IMPACT RESISTANCE

Apparatus

1) Suitable falling ball apparatus as described in ASTM D2794. Use male indentor ⅝ inch with no female die. Use a 2 lb weight.
2) Steel screed box as used in Bond Strength, Part 7—Apparatus.

Procedure

1) Draw down a 0.125 inch thick film on concrete brick as described in Part 7—Procedure. Let stand overnight.
2) Place concrete brick with thermoplastic film face up on the impact base, positioning the brick so that the impactor will hit the plastic

sample in the middle.
3) Raise the weight to the 50 inch-lb mark or as required in specification.
4) Release weight to impact on the sample.
5) Observe impact area for any cracks or loss of bond. Do not run more than 1 impact test on each brick.
6) Report pass or fail.

PART 10—YELLOW COLOR IN YELLOW THERMOPLASTIC

Apparatus

1) Hunter Color Difference Meter, 45° Illumination, 0° viewing or equivalent
2) CIE chromaticity charts for yellow with wavelength in region 580 to 584 nanometers
3) Aluminum disposable weighing dish, 63 mm wide and 17.5 mm deep. Fisher Scientific Catalogue Number 8-732-5C or equivalent

Procedure

1) With the 2 oz ladle, fill the aluminum dish with the hot thermoplastic from the Vollrath beaker.
2) Allow the dish to cool and strip aluminum from the sample.
3) Determine the Y, x, y values on the Hunter meter as outlined in California Test Method 660.
4) Plot the x and y values on the chromaticity chart and determine if the yellow color lies within specification limits. The brightness, Y, should also be within specification limits.
5) Save the sample for the Hardness Determination, Part 12.

PART 11—YELLOWNESS INDEX AND DAYLIGHT LUMINOUS REFLECTANCE IN WHITE THERMOPLASTIC

Apparatus

1) Photovolt Reflection Meter, Model 670 with Search Unit provided with Tristimulus filters, amber, blue and green or equivalent
2) Aluminum disposable weighing dish, 63 mm wide and 17.5 mm deep. Fisher Scientific Catalogue Number 8-732-5C or equivalent

Procedure

1) With the 2 oz ladle, fill the aluminum dish with the hot thermoplastic from the Vollrath beaker.
2) Allow the dish to cool and strip aluminum from the sample.
3) Calibrate the Photovolt Meter according to the manufacturer's instructions and measure the reflectance of the sample using the amber, blue and green Tristimulus filters.
4) Save the sample for the Hardness Test, Part 12.

Calculation

$$\text{Yellowness Index} = \frac{\text{Amber-Blue}}{\text{Green}} \times 100$$

Daylight Luminous Reflectance = Reflectance with the green filter

PART 12—HARDNESS

Apparatus

1) Shore Durometer Hardness Tester, Type A-2 with attached lead weights so that total weight of unit is 2002 grams
2) Incubator oven with glass inner door, capable of maintaining 115 ± 2°F
3) Stopwatch
4) Mold release

Procedure

1) Use the sample from Part 10 or Part 11
2) Place the sample on a metal one quart can lid previously coated with mold release to prevent sticking and place in the 115°F oven for 3 hours.
3) At same time place Durometer in oven.
4) After 3 hours, place Durometer on top of sample, immediately start stopwatch and close inner glass door.
5) After 15 seconds contact, read Durometer, open inner glass door, turn sample over and repeat Durometer reading.
6) Report the average of readings made on top and bottom of sample.

PART 13—ULTRAVIOLET LIGHT AND CONDENSATE EXPOSURE

Apparatus

1) QUV Accelerated Weathering Tester, as described in ASTM G53
2) 6 inch × 3 inch aluminum Q panels, Type A or equivalent
3) 2 inch wide duct tape
4) Steel screed box as described in Part 7—Apparatus
5) Oven capable of maintaining 425°F ± 2°
6) Photovolt Meter as decribed in Part 11—Apparatus

7) Hunter Color Difference Meter as described in Part 10—Apparatus
8) Masking tape, ½ inch wide

Procedure

1) One-half hour before test, place the screed box in the 425°F oven
2) Tape the 3 × 6 inch aluminum panel to the bench surface with masking tape to hold the panel firmly to the bench.
3) Remove the screed box from the oven and position at right angles to the 6 inch length of the aluminum panel and in the middle of the panel.
4) With the 1 oz ladle, remove a sample from the Vollrath beaker and quickly draw down the sample across the aluminum panel.
5) While hot, trim off excess plastic from the edges of the aluminum panel.
6) When cool, wrap top and bottom edges of the plastic sample with duct tape to keep the sample in position on the aluminum panel. Lap the edges of the plastic with no more than ¼ inch with the duct tape.
7) For the white thermoplastic, measure the yellowness index as described in Part 11.
8) For the yellow thermoplastic, measure the Y, x and y values as described in Part 10.
9) Expose sample for 300 hours in the QUV apparatus. Set the QUV for cycles of 4 hours UV exposure at 60°C and 4 hours condensate exposure at 40°C.
10) Remove samples from QUV and for the white sample, determine yellowness index and for the yellow sample, determine Y, x and y values.
11) Report yellowness index and chromaticity values.

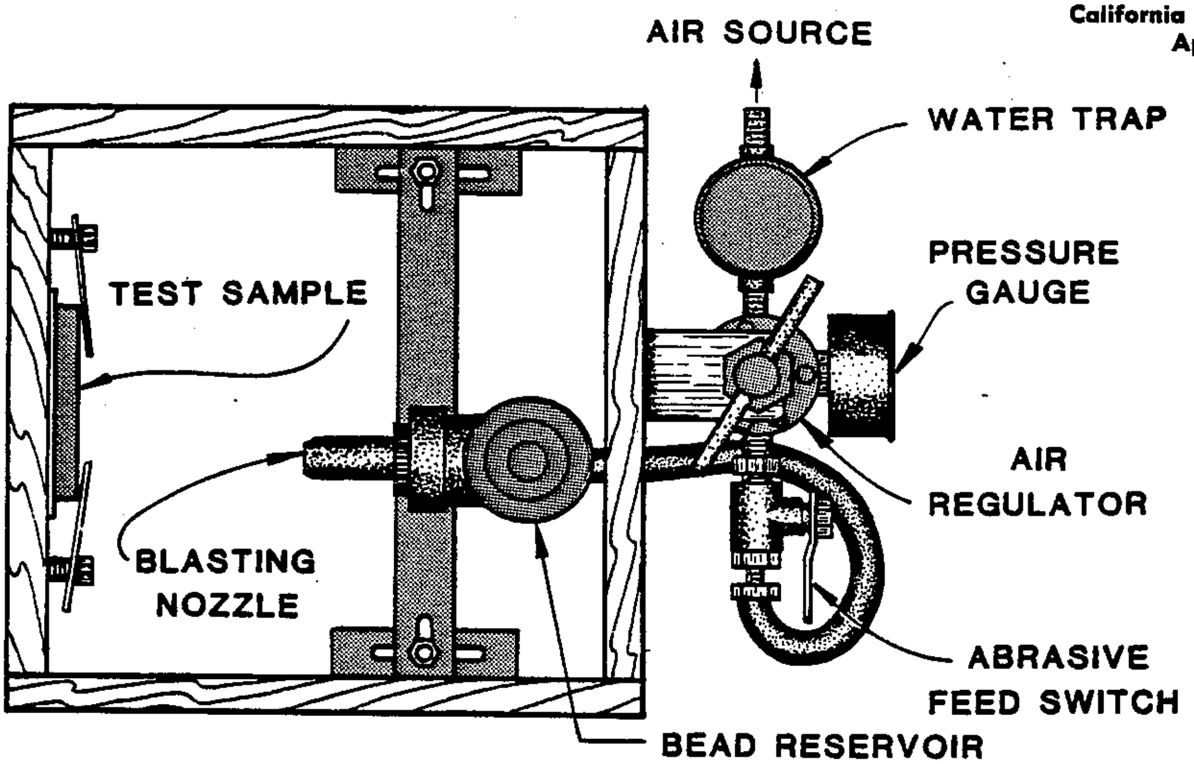
PART 14—ABRASION TEST

Apparatus

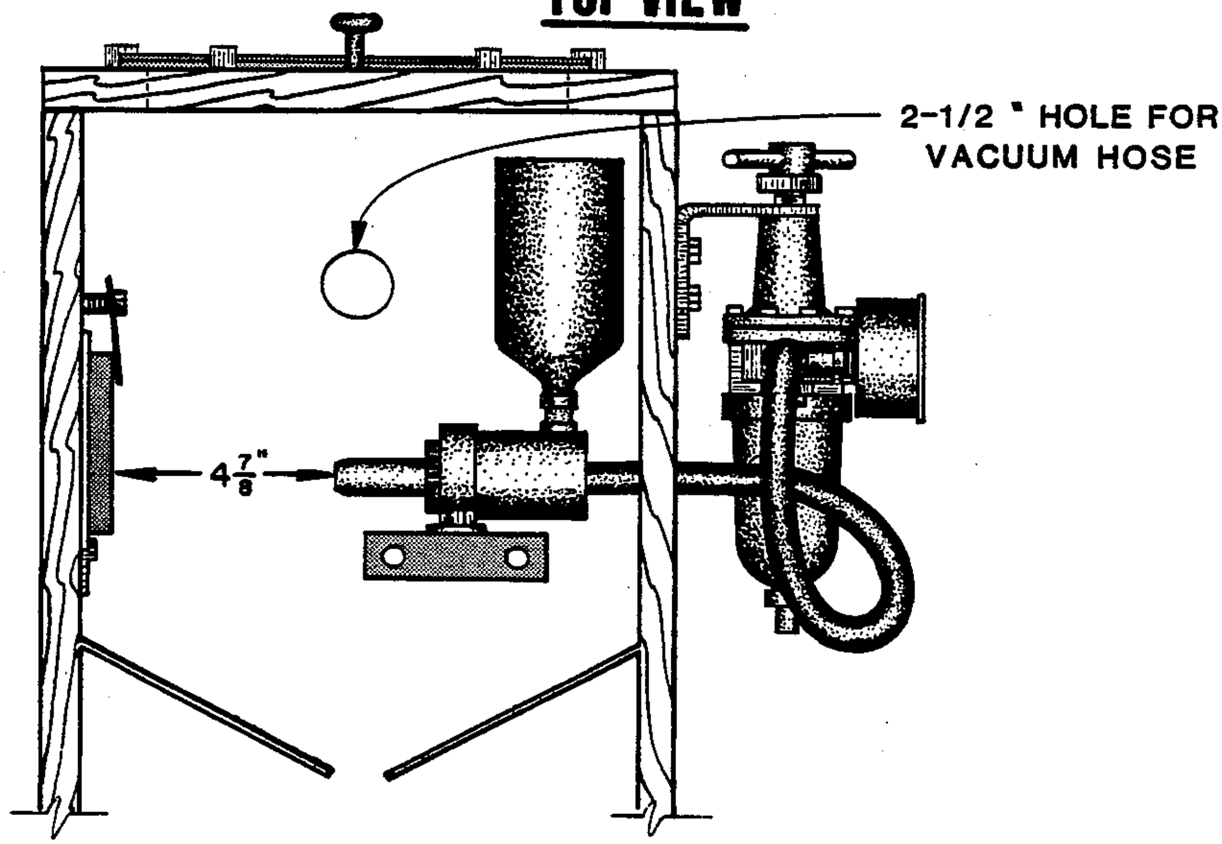
1) Blasting cabinet made from ¾-inch plywood and lined with steel sheeting. Inside dimensions are 12 × 12 × 12 inches with blasting nozzle, glass bead container, air pressure regulator and filter. The bottom of the unit has a removable drawer to catch the expended glass beads. The thermosplastic sample is held in position by metal clips and positioned as shown in the diagrams. The top of the unit has a hinged window to permit viewing, placing and removal of the sample. This apparatus is shown in Figures 4 and 5.
2) Glass beads, −25 +30 mesh
3) Steel sample mold, 4½ inches × 4½ inches × ½ inches as shown in Figure 6
4) Steel baseplate, 5 × 5 × ⅛ inches as shown in Figure 6
5) Mold release
6) Balance, at least 500 gram capacity, capable of weighing to 0.01 gram
7) Clean, dry, air supply to 40 psi
8) Vacuum cleaner to exhaust bead and dust particles

Procedure

1) Spray the steel sample mold with release agent and place concentrically on the 5 × 5 inch steel baseplate.
2) With the 2 oz ladle, remove enough hot thermoplastic from the Vollrath beaker to fill the sample mold.
3) When cool, loosen the mold screws and remove the mold.
4) Weigh the baseplate and thermoplastic.
5) Weigh 400 grams of the −25 +30 glass beads and fill bead container in blasting cabinet.
6) Position thermoplastic sample as shown in diagram so that blaster hits one corner of sample. Use the spring clips to keep sample in place.
7) Close hinged window, turn on air supply, set regulator at 22 psi, observe level of beads in glass bead container to see if they are flowing into blast nozzle. Check air pressure frequently to be sure regulator remains at 22 psi.
8) Turn on vacuum cleaner if available. The vacuum cleaner is not required but helps keep the surrounding area much cleaner.
9) When bead container is empty, close air valve, turn off vacuum cleaner and remove sample.
10) Brush off loose dust from sample and reweigh, noting the weight loss.
11) Place sample back in blasting cabinet and rotate 90° from original position so that a fresh corner may be blasted.
12) Repeat weighing and blasting until all 4 corners have been blasted.
13) Average the weight loss of the 4 corners. Maximum deviation among the 4 corners should be 0.5 gram.



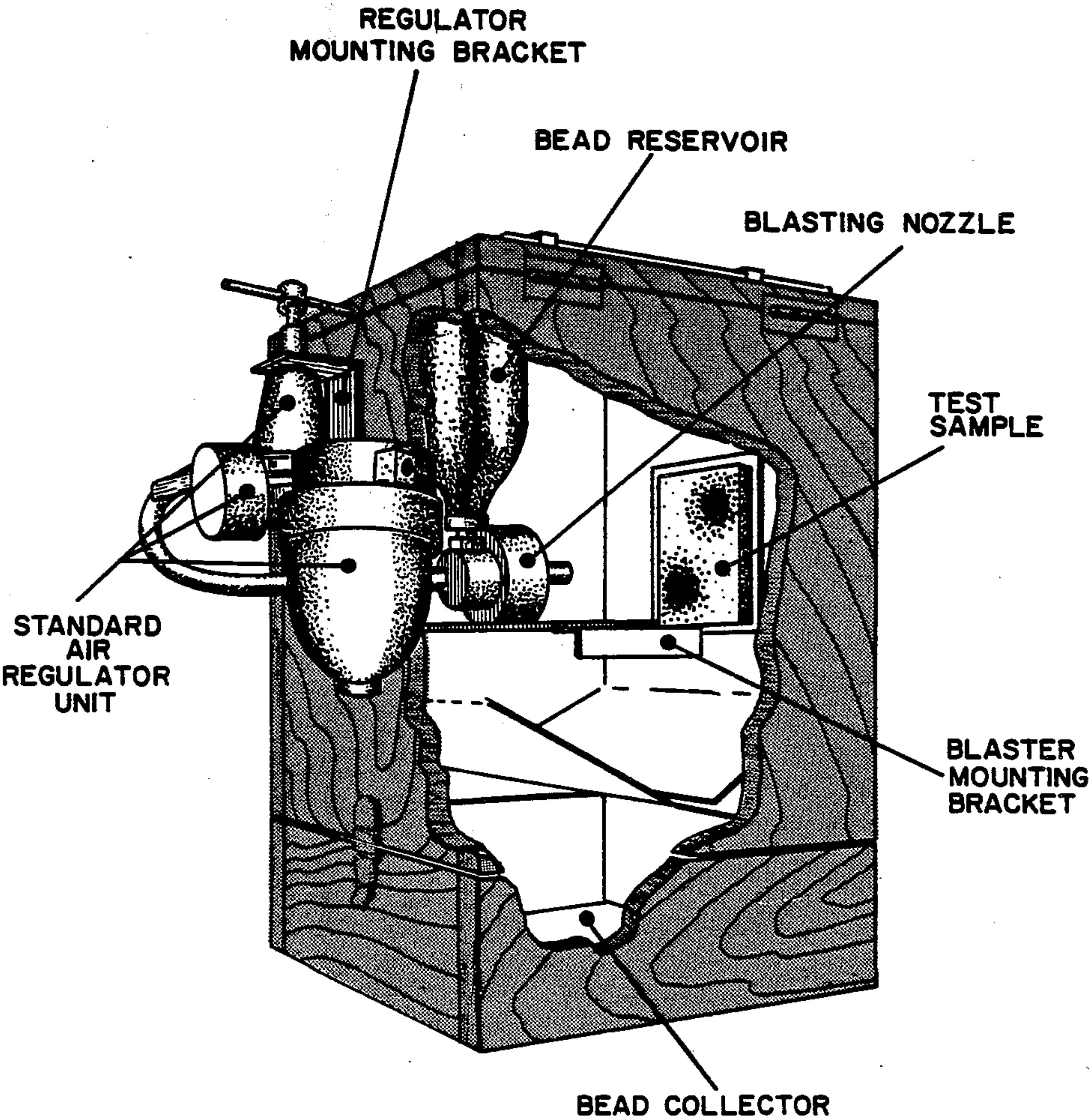
TOP VIEW



SIDE VIEW

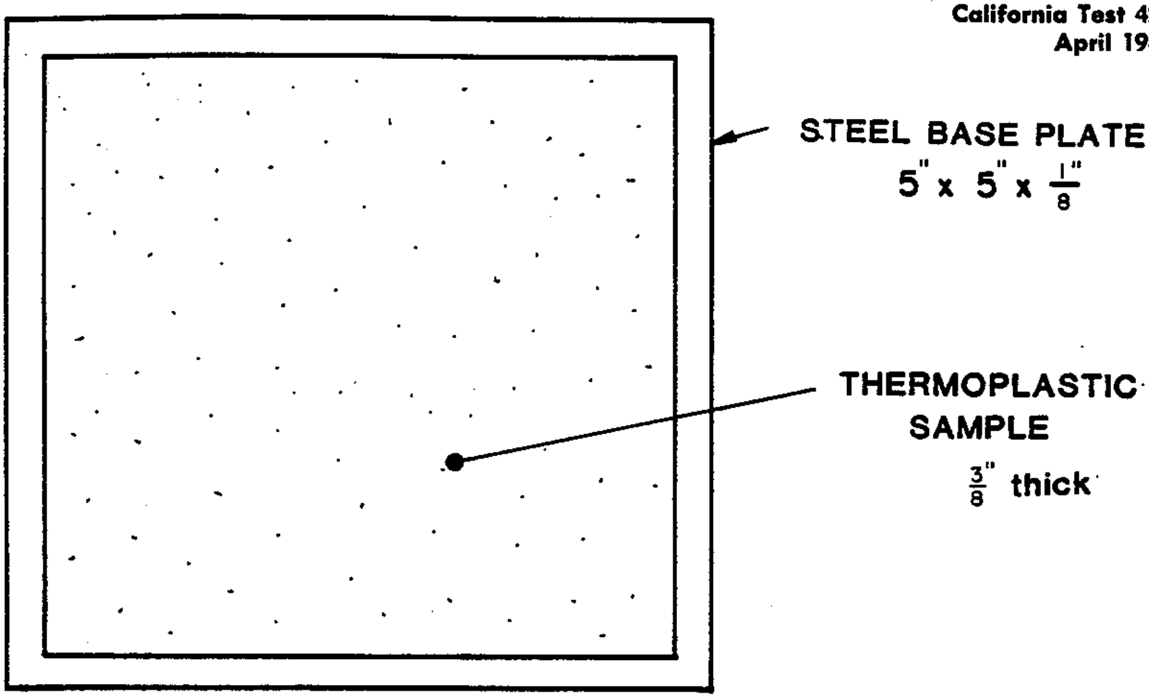
Figure 4

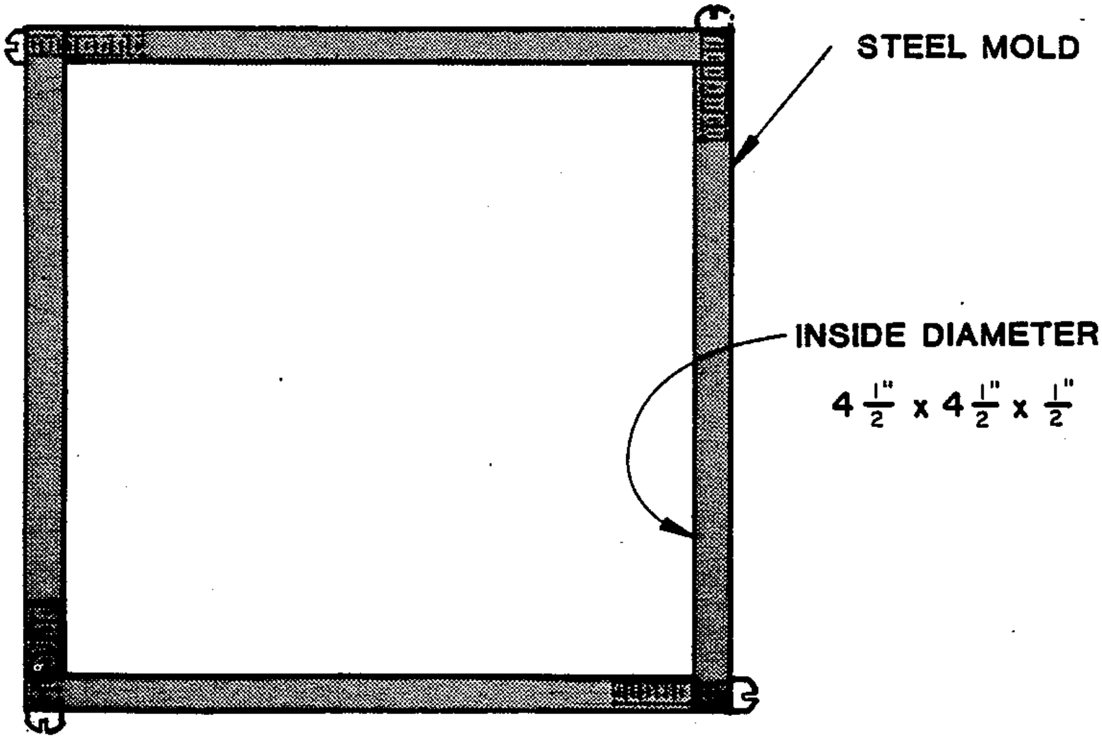
Some small hardware has been omitted .



GLASS BEAD ABRASION APPARATUS

Figure 5





TEST SAMPLE DETAILS

Figure 6

14) Do not blast down to the base metal on the baseplate. If sample blasts through before bead supply is exhausted, blast enough of one corner so that base metal does not show through, then stop blasting, remove sample, and rotate 90° to expose a fresh surface and continue blasting until beads have been used.

HAZARDS

1. When splitting out granular type material, wear approved type of respirator or dust mask. Wear safety glasses and gloves when handling the thermoplastic. Practice normal hygiene procedures, i.e., wash hands and face after handling the dry thermoplastic.

2. Due to the elevated temperatures involved in the testing of the thermoplastic, eye protection and suitable gloves are mandatory at all times when pouring samples and other tests involving the thermoplastic in the molten state.

3. If thermoplastic burns do occur, immediately flush affected area with *cold* water. Be aware of location of safety shower and cold water taps.

REPORTS OF RESULTS

Record results on Test Record Form TL 573

References: ASTM E11, G53, D2784, E28, E97, E313

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