

before and after the Thin-Film Oven Test. The Contractor shall do *|
 the Thin-Film Oven Test according to ASTM D 1754. The Contractor *|
 shall establish the specific gravity by pycnometer according to *|
 ASTM D 70 for use in the Thin-Film Oven Test. |

The Contractor shall calculate the two hundred seventy-five *|
 (275) degrees Fahrenheit viscosity ratio by dividing the viscosity *|
 after the Thin-Film Oven Test by the original two hundred seventy- *|
 five (275) degrees Fahrenheit viscosity. |

The Contractor shall separate the filler material from the |
 asphalt to establish the filler content and filler fineness. The *|
 Contractor shall consider the portion by weight of the adhesive *|
 insoluble in 1,1,1 - trichloroethane the filler content. The *|
 Contractor shall establish the filler content by weighing ten (10) *|
 + 0.01 grams of solid adhesive into a centrifuge flask with about *|
 one hundred (100) ml volume according to ASTM D 1796. The *|
 Contractor shall add fifty (50) ml of 1,1,1-trichloroethane to the *|
 adhesive. The Contractor should break them up into small pieces to *|
 speed the dissolution process. The Contractor shall swirl or stir *|
 them with a fine rod taking care not to lose solids. The Contractor *|
 shall place the sample flask in a balanced centrifuge and spin *|
 using a minimum relative centrifugal force of one hundred fifty |
 (150) according to Section 6 of ASTM D 1796 for ten (10) minutes. |
 The Contractor shall remove the sample flask and decant the solvent *|
 taking care not to lose solids. The Contractor shall repeat the *|
 application of solvent and centrifuging until the solvent becomes |
 clear and the filler is visually free of asphalt. The Contractor *|
 shall dry the filler at one hundred sixty (160) degrees + five (5) *|
 degrees Fahrenheit to remove solvent and weigh the resulting |
 filler. The Contractor may filtrate the decanted solvent to verify *|
 there is no loss of filler. The Contractor shall calculate percent *|
 filler content as follows: *|

$$\text{Filler Content, \% by wt} = \frac{(\text{Filler, wt. gm}) (100)}{\text{Original Adhesive wt, gm}}$$

The Contractor shall establish the filler fineness according *|
 to ASTM C 430 using numbers 325, 200 and 100 sieves. The Contractor *|
 shall modify this method by the use of a water soluble non-ionic *|
 wetting agent, such as Triton X-100, to aid the wetting action. *|
 Concentration of the surfactant solution shall be about one (1) |
 percent by weight. The Contractor shall wet one (1) gram dry sample *|
 thoroughly in the surfactant solution and allow to soak for thirty *|
 (30) minutes. The Contractor shall transfer the filler completely *|
 into the sieve cup and water spray applied for two (2) minutes. The *|
 Contractor may add surfactant solution as needed and physical means *|
 used to disperse clumped particles. The Contractor shall then dry *|
 and handle the sample according to ASTM C 430. *|

712.41

(5) **Packaging And Labeling.** The Contractor shall pack the adhesive *
in self-releasing cardboard containers, about ten (10) inch cube, *
that will stack properly. Containers shall have a net weight of |
about sixty-two (62) pounds. The label shall show the manufacturer, |
quantity and batch number. The Contractor shall print "Bituminous *
Adhesive for Pavement Markers" in bold lettering on the label. |

(C) **Certification.** The Contractor shall submit a certificate of *
compliance and certified test results showing that the adhesives conform *
to the contract. *

712.42 Irrigation Control System.

- (A) **Automatic Controller.** The Automatic Controller shall: *
- (1) be automatic, semi-automatic, or manual; *
 - (2) be in operation with twenty-four (24) hour clock; *
 - (3) be with minimum incremental starts of one (1) hour, fourteen *
(14) day; *
 - (4) be with minimum start variable or incremental timing from zero *
(0) to thirty (30) minutes; *
 - (5) be multiple or dual program capabilities; *
 - (6) be long station timing (5 hours or more) according to the *
irrigation program shown in the contract; *
 - (7) be electro-mechanical, solid-state electronic or microprocessor *
design; *
 - (8) operate on a minimum of one hundred fifteen (115) volts, single *
phase, alternating current or on a minimum of twenty-four (24) *
volts, single phase, alternating current with external 115-24 volts *
stepdown transformer; *
 - (9) supply a minimum of twenty-four (24) volts, current at the *
remote control valve; *
 - (10) have a rain-shut down switch that will cut out controller *
electrical output to the remote control valves and circuit breaker *
or fuse; *
 - (11) provide a master valve or pump circuit when called for in the *
contract; and *
 - (12) be pedestal or wall mounted as shown in the contract. *

The irrigation program settings shall be captive pins, levers, dials or keys. *|
*|

The Contractor shall: *|

(1) not use loose pins in the program settings; *|

(2) house the controller in a heavy duty weatherproof, sturdy, lockable housing with corrosion resistant finish; *|
*|

(3) have a door lock; and *|

(4) provide two (2) keys. *|

(5) install the controller according to the manufacturer's instruction and recommendations. *|
*|

(B) Master-Satellite Control System. The electric automatic master controller shall: *|
*|

(1) contain at least two (2) completely independent stations *|

(2) operate on one hundred twenty (120) volt single-phase, alternating current. *|
*|

(3) supply a thirty (30) volt continuous current for operation of the satellite controllers. *|
|

The Contractor shall equip the master controller the following: *|

(1) Full automatic operation and operate a complete fourteen (14) day minimum irrigation program.

(2) Twenty-four (24) hour clock with minimum incremental starts of one (1) hour.

(3) Circuit breaker protection for the controller and thirty (30) volt transformer.

(4) MANUAL-OFF-AUTOMATIC control switches.

(5) Timing and clock setting adjustments made without inserting or removing pins. Captive pins will be acceptable.

712.43 Pump, Motor and Motor Controller. The booster pump unit shall be according to the contract or the Contractor may substitute with an accepted prefabricated unit. *|
*|
*|

The pump shall be the centrifugal type with enclosed impeller, close coupled, single stage, single end suction, bronze fitted and mechanical seals. Pump discharge and total dynamic head requirements shall be according *|

712.43

to the contract. A NEMA listed drip-proof electric motor, two hundred forty *|
(240) volts, three (3) phase, sixty (60) hertz, one thousand seven hundred *|
fifty (1750) or three thousand five hundred (3500) revolution per minute shall *|
drive the pump. *|

With each pump unit motor, the Contractor shall provide an appropriately *|
sized, full voltage, magnetic starter having thermal overload and short *|
circuit protection in each phase in combination with a fused safety switch *|
according to Subsection 712.48(C) - Safety Switches in a NEMA 1 enclosure. *|
The Contractor shall hinge the enclosure cover. The Contractor shall cover *|
the overload reset as shall the control operator shown in the contract. The *|
motor shall conform to NEMA Standard MG 1. The controls and starters shall *|
conform to NEMA Standard ICS. The Contractor shall furnish a spare set of *|
fuses with each starter. *|

712.44 (Unassigned).

712.45 Mulch and Soil Amendments.

(A) Wood Chips. The Contractor shall get wood chips from clean, disease *|
free, green wood. The Engineer will not accept chips from kiln-dried or *|
air dried material. *|

The Contractor shall produce chips by machinery equipped with knives *|
or blades that cut rather than shred or break the material. The *|
Contractor shall grade the chips so that substantially the chips are from *|
half (1/2) to three (3) inches in length, half (1/2) to one and a half *|
(1-1/2) inches wide and one-eighth (1/8) to half (1/2) inch in thickness.

Chips used for mulching shall be free from leaves, twigs, shavings,
bark or material injurious to plant growth.

The Contractor shall fortify redwood chips with five (5) percent *|
nitrogen. The redwood chips shall be free of noxious weed seeds. *|

(B) Bagasse. Bagasse shall be the by-product of processed sugar cane
that were burned in the mill. Bagasse shall be free of noxious weed
seeds, fungus, agents and material considered harmful to plant growth.

712.46 Traffic Delineators.

(A) Delineator Tube. The delineator tube includes a medium density *|
flexible polyethylene or polyvinyl tubing and shall be fluorescent *|
orange-red in color. The delineator tube shall: *|

- (1) be forty-two (42) inches in height, *|
- (2) be four (4) inches in diameter, *|
- (3) have a wall thickness greater than 0.085 inch, *|

- (4) weigh about one and a half (1-1/2) pounds, and *|
- (5) provide three hundred sixty (360) degrees reflectorization. *|

The Contractor shall use two (2) four (4) inch strips of yellow-amber high reflective molded-prism reflecting material spaced about one and five eighths (1-5/8) inches apart. The Contractor shall arrange the strips one (1) above the other with the upper edge of the top strip one (1) inch from the tube top. The Contractor shall attach the strips firmly to the tube so that no slippage of the strips occurs. *|

The tube shall have a smooth continuous surface free from cracks, seams, blisters and be damage resistant.

(B) Delineator Base. The Contractor shall interlock the delineator base securely to the tube and shall be more than one (1) inch in height, weigh more than thirteen (13) pounds and the least width dimension shall be more than fifteen (15) inches. The resultant base shall have sufficient stability to keep tube in upright position under normal wind conditions. The base includes a heavy rubber components with added paraffin preservatives for weather protection. *|

(C) The Contractor shall be able to disassemble and stack the delineator. The Contractor shall not use metal parts. *|

712.47 Springs for Sprinkler Risers. Springs for sprinkler risers shall be a compression spring, commercially manufactured from 0.187 inch diameter (OTMB) spring wire. The coil shall have an inside diameter of 0.900 inch to 0.920 inch and be wound at a pitch of 0.475 inch. The Contractor shall square the spring ends only. *|

712.48 Electrical Appurtenances. Miscellaneous electrical appurtenances shall comply with the following:

(A) Circuit Breakers. Individually enclosed circuit breakers for pump motor feeder protection shall be molded case type conforming to UL 489 in NEMA type 1, hinged door enclosure. Each pole shall provide inverse time delay overload and instantaneous short circuit protection. Terminals shall be pressure type, size to ease the wire sizes indicated. Breakers shall be lockable in either position. Breakers shall be three (3) pole, four hundred and eighty (480) volts, with interrupting rating of fourteen thousand (14,000) symmetrical amperes at rated voltage, and continuous current rating shown in the contract. Individually enclosed circuit breakers for other than pump motor feeder protection shall be as specified herein for panelboard circuit breakers. *|

(B) Panelboards. Panelboards shall conform to UL 67 and shall be complete with NEMA type 1 enclosure. Panelboard circuit breakers shall conform to UL 489 and shall be one (1) pole, two hundred and forty (240) volts, with interrupting rating of ten thousand (10,000) *|

symmetrical amperes at rated voltage, and continuous current rating shown in the contract. The Contractor shall provide the panelboards with an insulated, groundable neutral bus. *|
*|

(C) **Safety Switches.** Safety switches used in combination with motor starters shall conform to UL 98 and shall be heavy duty type, sized and equipped with fuses sized appropriately to the motor served. Switches shall be three (3) pole, rated two hundred forty (240) volts.

(D) **Snap Switches.** Snap switches used for on-off control of power to circuits of one hundred twenty (120) volts and less shall be one (1) pole, twenty (20) amperes, and shall conform to UL 20. The Contractor shall mount the switches in an enclosure to prevent accidental contact with live parts. *|
*|

(E) **Meter and Service Equipment Cabinet.** Cabinets shall be of welded steel construction shown in the contract and of the size or larger required to ease the accepted equipment. Door hinging shall be tamper-proof and locking according to the contract. Backboard shall be exterior grade plywood finished on one (1) side, treated to repel fungi and insect attack, and fixed to the cabinet by peripheral application of two (2) part epoxy cement and bolting in the shop. The entire cabinet shall be shop painted with paint conforming to Subsection 708.03 - Dark Green Enamel Paint. Cabinet shall be of raintight construction equivalent to NEMA 3R. |

(F) **Transformers.** Transformers shall be dry, of the ratings shown in the contract, totally enclosed in a weatherproof case having integral wiring compartment. Transformers shall conform to NEMA Standard ST 1 and shall have the standard primary voltage taps specified in the NEMA standard. Insulation rating shall be one hundred fifteen (115) degrees Celsius rise, Class F. |

(G) **Meter Sockets.** Meter sockets shall be seven (7) jaw, for self-contained meters according to the utility company. *|

(H) **Ground Rods.** Ground rods shall be copper-encased steel rolled to a commercially round shape from a welded, copper-encased steel made by the molten welding process or by the electro-formed molecularly-bonded process. The ground rods shall have a hard, clean, smooth, continuous, copper surface of 0.013 inch minimum thickness.

(I) **Receptacles.** Receptacles shall be duplex, fifteen (15) ampere, one hundred twenty-five (125) volt, NEMA configuration 5-15R, mounted in sheet metal box, with cover conforming to UL Standard 514.

712.49 Valve Boxes and Covers (Plastic and Concrete).

(A) **Plastic Valve Boxes and Covers.** Plastic valve boxes shall be of similar sizes as the concrete valve boxes and no larger than type "X" valve box.

The plastic valve box covers shall be green in color with the marking of "IRRIGATION CONTROL VALVE" or "CONTROL VALVE". The *| Manufacturer shall make and construct plastic valve boxes and covers *| commercially of polyolefin and fibrous components; HDPE (High Density *| Polyethylene); or ABS (Acrylonitrile-Butadiene-Styrene).

The plastic materials shall conform to the following physical properties:

Physical Properties	ASTM Test	Minimum Value For Plastic Material		
		Polyolefin & Fibrous Comp.	HDPE	ABS
Tensile Strength (psi)	D 638	3,400	2,250	6,000
Flexural Modulus (psi)	D 690	191,000	123,800	320,000
Impact Strength (ft.-lb./in.)	D 256	0.6	Notch 1.98 Unnotch 6.15	6.7
Deflection Temp °F. @ 66 psi	D 648	2.30	153	222

When placed in compacted backfill according to the contract, the *| plastic valve boxes and covers shall support the following vertical *| loads applied uniformly on the cover:

Type A	1100 pounds
Type B	2400 pounds
Type X	4800 pounds

Plastic valve boxes shall be of the dimensions:

Plastic Box		*Excluding web
Type	*Minimum Wall Thickness, Inches	Depth, Inches
A	5/16	10±
B	5/16	12
X	5/16	12

Plastic valve covers shall be of the dimensions:

PLASTIC COVER				
Type	Length Inches	Width Inches	Minimum Edge Thickness, Inches	Diameter Inches
A	--	--	2	9-1/8±1/4
B	15-3/8±1/8	10-1/8±1/8	1-3/4	--
X	20 to 23	13-3/4 to 14	2	--

(B) **Concrete Valve Boxes and Covers.** The Contractor shall make concrete valve boxes of portland cement concrete. The concrete valve box shall have a compressive strength of at least two thousand five hundred (2,500) pounds per square inch and conform to Section 601 - Structural Concrete. The maximum density of the concrete in the finished product shall be one hundred fifteen (115) pounds per cubic foot and the maximum absorption shall be fifteen (15) pounds per cubic foot. The combined aggregates shall be of such composition of sizes that the surface of the finished product shall be continuous and of a uniform texture.

Covers for Type "A" concrete valve boxes shall be concrete, cast iron or zinc-coated steel. Covers for Types "B" and "X" concrete valve boxes shall be cast iron or zinc-coated steel.

Concrete valve boxes and covers shall have the following dimensions:

CONCRETE BOX					
Type	Minimum Wall Thickness, Inches	Depth, Inches	Minimum Inside Dimension		
			Length Inches	Width, Inches	Diameter Inches
A	1	12	--	--	6-7/8
B	1	11 - 12	17-1/4	9-3/8	--
X	1	12	21-1/2	12-1/2	--

COVER				
Type	Length Inches	Width Inches	Minimum Edge Thickness, Inches	Diameter Inches
A	--	--	2	7-3/4
B	14-1/2	8-3/4	1-1/8	--
X	22-1/8	13-1/8	1-1/8	--

712.50 Switching Tensiometer.

(A) **Bourdon-Tube Type.** Switching tensiometer includes an air-tight, water-filled tube with porous ceramic tip at the bottom and vacuum gage with switch. The tube shall be clear plastic, extremely rigid and heavy walled. The tube shall be inert to weather and soil. The porous ceramic tip shall provide high flow rate for sensitive response. The Contractor shall bond the porous ceramic tip to the tube. The vacuum dial gage shall have a two (2) inch diameter dial face that is graduated from zero (0) to one hundred (100) centibars of soil suction. The Contractor shall protect the housing against weather and shock. The gage shall have a positive On/Off switch that the a person can adjust from zero (0) to one hundred (100) centibars. Electrical capacity of the unit shall be twenty-four (24) volts, alternating current or direct current, half (1/2) ampere, ten (10) watts. The Contractor shall provide wire leads to the switch for connection to the controller or solenoid valve.

(B) **Solid State Type.** The solid state tensiometer shall operate on the principle of heat diffusion. The Contractor shall power the solid state tensiometer by alternating current, fifteen (15) watts of power. The Contractor shall connect the solid state tensiometer in series with each remote control valve cable to supervise the irrigation controls. The tensiometer shall have a preset stress valve of twenty-four (24) centibars and an override switch at the top of the tensiometer.

When shown in the contract, the Contractor shall connect one (1) solid state tensiometer to each remote control valve.

712.51 Flexible Delineator Post.

(A) **General.** The post material shall be of a flexible and durable material, resistant to impact, ultra violet light, ozone, hydrocarbons, and stiffening with age. The post shall be according to the contract and free of burns, discoloration, contamination, and other objectionable marks or defects that affect appearance and serviceability.

The post shall be opaque white or yellow. The opaque yellow post's yellowness index shall be within the green and red tolerance limits when compared to the FHWA Standard Color Chips For Highway Signs. The opaque white's yellowness index shall not exceed twelve (12) when tested *| according to ASTM D 1925 or E 313. The Contractor shall expose the post *| materials for one thousand (1000) hours in an Atlas Type B and BH Xenon *| Arc Weatherometer (ASTM G 26) with no significant fading or darkening.

The Contractor shall condition the post a minimum of two (2) hours *| in an oven at one hundred forty (140) + three (3) degrees Fahrenheit. The conditioned post shall be able to straighten itself within thirty | (30) seconds when bent one hundred eighty (180) degrees at the midpoint for each of four (4) bends. The Contractor shall complete the test on *| each post within two and a half (2-1/2) minutes of removal from the oven. The post shall be sufficiently rigid to resist wilting after conditioning a minimum of two (2) hours at one hundred eighty (180) degrees + three (3) degrees Fahrenheit.

The post shall provide a height of forty-eight (48) inches above | the pavement surface. The manufacturer shall design the post and base *| anchor to ease a permanent installation that shall resist overturning, *| twisting, and displacement from wind and impact forces.

The manufacture shall design the post so the Contractor may install *| a three (3) inch by twelve inch reflector on the top fourteen (14) *| inches of the post. The top fourteen (14) inches shall be relatively *| flat so the Contractor may install a thirty-six (36) square inches of *| reflective surface facing in one (1) direction.

The manufacturer shall make the post from an impact resistant *| material. The manufacturer shall design the post to be self erecting *| and remain serviceable after being subjected to a series of direct *| impacts by a three thousand five hundred (3500) to four thousand five hundred (4500) pounds passenger sedan at temperatures of forty (40) degrees Fahrenheit or above. The Contractor shall install the posts *| according to the recommendations of the manufacturer. The Contractor *| shall furnish the post complete with the attached reflectors proposed for use. Posts shall withstand a series of five (5) impacts at seventy- *| five (75) degrees angle into the traffic face of the post at a speed of fifty-five (55) miles per hour. The post shall have no splitting or delaminating damage due to the impacts. The posts shall also be of sufficient rigidity to remain upright in high wind conditions. The impacting vehicle shall suffer little or no damage during the impact test series. The Engineer shall determine final acceptability according *| to the contract. *|

The Contractor shall provide special tools or accessories necessary *| for installation on an incidental basis. *|

(B) **Type A Delineator.** The manufacturer shall design the Type A *|
delineator for installation on paved areas. The manufacturer shall *|
design the anchor to be bonded to the pavement. The manufacturer shall *|
provide detailed installation instruction. *|

(C) **Type B Delineator.** The manufacturer shall design the Type B *|
delineator for installation on unpaved areas. The manufacturer shall *|
design the post for an anchoring depth of less than twenty-four (24) *|
inches. The manufacturer shall provide detailed installation *|
instruction. *|

(D) **Reflectors.** The reflector shall be impact resistant subject to
acceptance by the Engineer. The reflector shall be white or yellow
according to Subsection 712.21 - Reflector Marker. The reflector *|
dimensions shall be according to the contract. *|

The Contractor shall mount the reflector on the top fourteen (14) *|
inches of the post with the reflector facing in the direction of the *|
oncoming traffic. The Contractor shall mount the reflector by positive *|
means that has adequate strength to prevent loss of the reflector during |
the life of the post. The reflector shall be free of scratches,
abrasions, and other physical damage for acceptance.

(E) **Packaging.** The Contractor shall mark each carton with the *|
manufacturer's code or lot number, quantity in carton, and type of post *|
in the carton.

(F) **Prerequisite for Acceptance.** The manufacturer shall submit a
certified test report with test data, developed by a testing laboratory
acceptable to the State that attests that their marker post complies *|
with the contract. Test data submitted by the manufacturer may be *|
subject to verification by suitable tests conducted by the Hawaii State
Department of Transportation before acceptance. *|

--(G) **Sampling and Acceptance.**

(1) **Sampling.** The Engineer may require a minimum of six (6) *|
samples for testing and acceptance. *|

(2) **Acceptance.** A minimum of five (5) of six (6) samples shall |
pass the test according to the contract. *|

712.52 Rain Sensor Switch. The rain switch control shall be a device that
prevents irrigation during periods of rain, but does not interfere with the
irrigation control program system.

The device shall be automatic and shall be compatible to the irrigation
control system.

712.53 Preformed Pavement Marking Tape.

(A) **General.** The preformed pavement marking tape includes a film with glass beads on a conformable backing precoated with a pressure sensitive adhesive. The tape shall adhere to asphalt concrete or portland cement concrete without the use of heat, solvents or other additional adhesive means and immediately ready for traffic after application.

The size, quality and refractive index of the glass beads shall be such that the performance requirements as specified herein are met. The manufacturer shall make the tape so that a person cannot remove the beads easily when a person scratches the material surface with a thumbnail.

The preformed pavement marking tape shall contain selected pigments blended to provide standard highway colors of white or yellow. The tape shall maintain a uniform color under both daylight and night lighting conditions throughout its expected life.

Preformed words and symbols shall conform to the applicable shapes and sizes outlined in the latest edition of the FHWA publication, MUTCD.

When stored in a cool, dry area indoors, the tape shall be suitable for use a minimum of one (1) year after the date of purchase.

(B) **Classification.** Preformed pavement marking tape shall be of various types and compositions and for applications specified as follows:

(1) **Temporary Preformed Pavement Marking Tape.** Temporary tape shall perform for the duration of a normal construction period and then remove intact or in large pieces.

(2) **Permanent Preformed Pavement Marking Tape.**

(a) **Type I.** The Contractor shall use Type I permanent tape for high traffic volume and severe wear conditions such as repeated shear action from crossover and stop, start, or turn movements. Removal should not be easy.

(b) **Type II.** The Contractor shall use Type II permanent tape for highway edge of pavement lines. The tape shall carry out satisfactorily when subjected to low traffic volumes, less severe wear action than for Type I and primarily free rolling traffic.

(c) **Type III.** The Contractor shall use Type III permanent tape for symbols, legends and intersection markings such as stopbars and crosswalks in areas of high wear.

(C) **Reflectance.** The films shall have the initial minimum reflectance values of 0.2 degree and 0.5 degree observation angles and an entrance angle of eighty-six (86) degrees as measured according to the testing procedure of Federal Test Method Standard 370. The photometric quantity to be measured shall be specific luminance (SL), and shall be expressed as millicandelas per square foot per foot candle (mcd/ft.²/fc).

INITIAL MINIMUM REFLECTANCE VALUE					
Observation Angle Classification		Specific Luminance (mcd/ft. ² /f _c)			
		White		Yellow	
		0.2°	0.5°	0.2°	0.5°
Temporary	<u>Removable</u>	1770	1270	1310	810
Permanent	<u>Type I Centerline</u>	550	380	410	250
Permanent	<u>Type II Edge Line</u>	960	760	680	510
Permanent	<u>Type III Intersection</u>	550	300	410	250

The sample size shall be two (2) feet by two and a half (2-1/2) feet and the test distance shall be fifty (50) feet. The angular aperture of the photo receptor and light projector shall be six (6) minutes of arc. The reference center shall be the geometric center of the sample, and the reference axis shall be taken perpendicular to the test sample.

(D) **Skid Resistance.** The surface of the preformed pavement marking tapes shall provide an initial minimum skid resistance value of forty-five (45) BPN when tested in accordance with ASTM E 303.

(E) **Temporary Preformed Pavement Marking Tape.**

(1) **Composition.** The tape shall be a highly reflective, conformable, pliant polymer material intended for marking applications where removability is required.

The tape includes a mixture of high quality polymeric materials and pigments and shall not contain metallic foil. The manufacturer shall distribute the glass beads throughout the pigmented area and in a reflective layer bonded to the top surface. The performance of the glass beads shall meet the durability and reflectance criteria according to the contract. The manufacturer reinforce the tape with a non-metallic medium and precoat the tape with a pressure sensitive adhesive. The tape shall adhere to roadway surfaces under climatic and traffic conditions normally met in the construction work zone. The Contractor shall be able to expose the newly applied tape immediately to traffic without pickup or distortion by vehicles. *|

(2) **Thickness.** The film without adhesive shall have a minimum thickness of 0.03 inch.

(3) **Removability.** The tape shall be removable from asphalt cement concrete or portland cement concrete manually or with a roll-up device at temperatures above forty (40) degrees Fahrenheit and without the use of heat, solvents, grinding or sandblasting. The tape shall meet this requirement even after traffic exposure on transverse applications according to the following: *|

- (a) Time in place - 632 days.
- (b) ADT per lane - 9000 (23% Trucks, 3.5 axles/unit).
- (c) Minimum axle hits - 13,000,000.

(F) Permanent Preformed Pavement Marking Tape.

(1) Type I.

(a) **Composition.** The Type I tape includes a mixture of high quality polymeric materials, pigments and glass beads, with a reflective layer of beads bonded to the top surface. *|

(b) **Thickness.** The film without adhesive shall have a minimum thickness of 0.06 inch.

(c) **Conformability and Patchability.** The tape shall conform to pavement contours, breaks, and faults through the action of traffic at normal pavement temperatures. Worn or missing areas shall be repairable with butt spliced patches of the same material. |

(d) **Tensile Strength and Elongation.** The tape shall have a minimum tensile strength of forty (40) pounds per square inch and a minimum elongation of seventy-five (75) percent at break when tested according to ASTM D 638. The sample size shall be *|

six (6) inches by one (1) inch. The Contractor shall test the sample at a temperature between seventy (70) degrees Fahrenheit and eighty (80) degrees Fahrenheit with a jaw speed of ten (10) to twelve (12) inches per minute. *

(e) Reflectivity Retention. The manufacturer shall bond the glass beads strongly so traffic cannot remove the glass beads easily. The manufacturer shall test the tape for reflectivity retention as follows: *

1. The manufacturer shall bend a sample two (2) inches by six (6) inches around a half (1/2) inch diameter mandrel with the two (2) inch dimension perpendicular to the mandrel axis. Examination of the area with a 5x magnifier shall show less than ten (10) percent of the beads with forty (40) percent or less embedment in the binder. *

2. **Taber Abraser Simulation Test.** Using a Taber Abraser with an H-18 wheel and a one hundred twenty-five (125) gram load, the manufacturer shall test a sample for two hundred (200) cycles and then inspect with a magnifier of five (5) power or larger. *

The test shall not lose more than fifteen (15) percent of the beads due to popout and bead erosion shall be the major mode of failure. *

(f) Effective Performance. The tape shall be neat and durable and shall not flow or distort due to temperature or vehicle impacts. The pliant polymer shall provide a cushioned, resilient substrate that shall reduce bead crushing and loss for the life of the marking. The film shall be weather resistant and shall show no appreciable fading, lifting or shrinkage throughout its usage. The tape shall show no significant tearing, roll back, or other signs of poor adhesion during its useful life which shall be a minimum of one (1) year from the date of installation.

Immediately after application, the tape shall impact by vehicles without being picked up or distorted. |

The Contractor shall also install Type I and Type II tape on newly laid asphaltic concrete pavements and roll the tape into place without loss of performance characteristics. *

(2) Type II.

(a) **Composition.** The retroreflective pavement marking material includes glass beads embedded in a white or yellow film with a thin, flexible conformable backing. The manufacture shall precoat the backing with a pressure sensitive adhesive.

(b) **Thickness.** The film with adhesive shall have a minimum thickness of 0.025 inch.

(c) **Abrasive Resistance.** Samples of test material shall not wear through to the conformable backing surface in less than four hundred (400) cycles when tested according to Federal Test Method Standard 141, Method 6192, except using an H-22 wheel and a two hundred and fifty (250) gram load.

(d) **Acid resistance.** The beads shall show resistance to etching, hazing or delamination of bead surface after exposure to a one (1) percent solution of sulfuric acid. The Contractor shall test the beads as follows:

1. Soak one (1) gram of beads in one hundred (100) cc of a one (1) percent H_2SO_4 solution for one hundred (100) hours.

2. Then decant the acid solution and dry the beads at one hundred (100) degrees Celsius.

3. Microscopic examination of a sample of the beads shall show no more than five (5) percent of the beads altered by the acid.

(e) **Reflectivity Retention.** The requirements shall according to Subsection 712.53(F)(1)(e) - Reflectivity Retention.

(f) **Effective Performance.** The requirements shall be according to Subsection 712.53(F)(1)(f) - Effective Performance.

(3) Type III

(a) **Composition.** The adhesive coated retroreflective pavement marking film includes a mixture of high quality polymeric materials, pigments and glare beads distributed throughout its base cross-sectional area, with a reflective layer of beads bonded to the top urethane wear surface. The Contractor shall precoat the film with a pressure sensitive adhesive. The edges of the preformed tape shall be clean cut and true.

(b) **Thickness.** The film (excluding the adhesive) shall have a minimum thickness of 0.06 inch.

(c) **Conformability and Patchability.** The requirements shall be according to Subsection 712.53(F)(1)(c) - Conformability and Patchability.

(d) **Tensile Strength and Elongation.** The tape shall have a minimum tensile strength of three hundred (300) pounds per square inch and a minimum elongation of seventy-five (75) percent at break when tested according to ASTM D 638. The sample size shall be six (6) inches by one (1) inch. The Contractor shall test the sample at a temperature between seventy (70) degrees Fahrenheit and eighty (80) degrees Fahrenheit with a jaw speed of ten (10) to twelve (12) inches per minute.

(e) **Reflectivity Retention.** The manufacturer shall bond the glass beads strongly so traffic cannot remove the glass beads easily. The test shall not lose more than fifteen (15) percent of the beads due to popout. The predominant mode of failure shall be "wear down" of the beads at two hundred (200) cycles when using a Taber Abraser with an H-18 wheel and a one hundred and twenty-five (125) gram load.

(f) **Glass Bead Retention.** When a two (2) inch by six (6) inch sample is bent over a half (1/2) inch diameter mandrel (with the 2 inch dimension perpendicular to the mandrel axis) microscopic examination of the area on the mandrel shall show no more than ten (10) percent of the beads with entrapment by the binder of less than forty (40) percent.

(g) **Installation.** The Contractor shall apply and tamp the markings according to the manufacturer's recommendations.

(h) **Effective Performance.** The requirements shall be according to Subsection 712.53(F)(1)(f) - Effective Performance.

712.54 Epoxy Sealer. Epoxy sealer shall be a high viscosity liquid epoxy formulated primarily for use in sealing inductive wire loops and leads imbedded in asphalt concrete and portland cement concrete for traffic signal controls and vehicle counters. The Contractor shall use this epoxy for repair work on existing spalls, cracks and other deformations in and around saw cuts housing inductive loops and leads. The rapid cure allows minimum traffic delay. The Contractor shall be able to place this sealant on grades up to fifteen (15) percent without excessive flow of the material.

(A) Composition.

Component A	Parts by Weight
Epoxy Resin ¹	85.00
Orthocresol Glycidyl Ether ²	15.00
Titanium Dioxide, ASTM D 476, Type III or IV	2.00
Colloidal Silica ³	1.50
Glycerine, ASTM D 1257	0.50
Silicone Anti-Foam, Type Q	0.01

Component B	Parts by Weight
High Functionality Polymercaptan Hardener ⁴	40.00
N-Aminoethyl Piperazine ⁵	10.00
2, 4, 6-Tri (Dimethyl-aminomethyl) Phenol ⁶	4.00
Polysulfide Polymer ⁷	48.94
Colloidal Silica ³	1.00
Glycerine, ASTM D 1257 ⁸	0.50
Carbon Black	0.10
Silicone Anti-Foam, Type Q	0.01

¹ Di glycidyl ether of bisphenol A, viscosity, 100-160 poise at 25 degrees C; epoxide equivalent 180-200. Color, Gardner 1933, 3 max.

² Viscosity at 25 degrees C., 5-10 Centipoise. Weight per gallon 9.00-9.10 pounds. Epoxide equivalent 180-200.

³ SiO₂, (moisture-free basis), 99 percent minimum; refractive index, 1.46; surface area, 175-225 square meters per gram; particle size 0.015 microns; pH (4 percent aqueous dispersion), 3.5-4.2; pour density, 2.3 lbs./cu. ft. maximum; free moisture at 105 degrees C., one (1) percent maximum.

⁴ Liquid polymercaptan resin, viscosity 100-130 poise at 25 degrees C; specific gravity 1.14-1.16; mercaptan value, 3.6 meq/gram. Color, Gardner 1933, 1.

⁵ Color (APHA) 50 maximum, amine value 1250-1350 based on titration that reacts with the 3 nitrogens in the molecule; appearance clean and substantially free of suspended matter.

⁶ Formula weight 265; specific gravity at 25 degrees C; distillation range 96 percent at 130 degrees C to 160 degrees C (0.5-1.5 mm.); flash point, Tag Open Cup, 300 degrees F minimum; water content 0.06 percent maximum.

⁷ Specific gravity, 1.24-1.30 at 20 degrees/20 degrees C; viscosity, 700-1200 centipoise, Brookfield at 25 degrees C; pH water extract, 6.0-8.0; moisture content, 0.1 percent maximum; pour point, -15 degrees F; average molecular weight, 1000; flash point, degrees F, Cleveland Open Cup, 390 minimum; sulfur content, percent, 36-40; color, Hellige, 9-12. The product shall be difunctional mercaptan made from 98 mole percent of bis (2-chloroethyl) phenol and 2 mole percent of trichloropropane.

⁸ Surface area, square meters/gram, 80-150; particle diameter millicrons, 18-30; pH, 7.0-8.5; fixed carbon (moisture free), percent, 96-98; volatile matter, 1-4; oil absorption, stiff past endpoint, CC/gram, 0.75-0.90.

(B) Characteristics of Components.

	Component A	Component B
Viscosity, poise, Brookfield	100-250	100-250
Shear Ratio (minimum)	2.0	1.8

(C) Characteristics of Combined Components.

Gel Time (minutes)	13 to 18
On 1/8 of an inch cast sheet, cured 18 hours at 77 degrees F. ± 5 hours at 158 degrees F.	
Tensile Strength, psi (minimum)	400
Elongation, percent (minimum)	90
Shore D Hardness (minimum)	45
Color	Color No. 26081 to Color No. 26173 of Federal Standard No. 595.

(D) Directions for Use. The Contractor shall blow the saw cuts clean *| and dry with compressed air to remove the excess moisture and debris. *| For repairing damaged saw cuts, the Contractor shall clean loose, *| spalled material away from saw cut, chipping back to sound asphalt *| concrete or portland cement concrete and loose material cleaned from |

loop wires. The mixing ratio by volume is one (1) part of Component "A" to one (1) part of Component "B". The Contractor shall mix only the amount the Contractor can use within ten (10) minutes from the time the Contractor starts mixing operations.

712.55 Reflective Thermoplastic Compound Pavement Markings.

(A) General. Reflective thermoplastic compound pavement markings shall be a substance free of volatiles that:

(1) is machine applied to the pavement surface in a hot molten state and

(2) after cooling to the ambient temperature and without polymerization or other chemical change, forms a traffic marking stripe of the quality and appearance according to the contract.

The material used shall be a product especially compounded for traffic markings.

The installed stripe shall not be slippery when wet.

The compound shall not deteriorate by contact with sodium chloride, calcium chloride, oil content of pavement materials, or from oil droppings from traffic.

In the plastic state, the material shall not give off fumes that are toxic or injurious to persons or property. The material shall not break down or deteriorate if held at the plastic temperature for a period of four (4) hours, or by reason of four (4) reheatings to the plastic temperature.

There shall be no obvious change in color of the material as a result of up to four (4) reheatings, or from batch to batch.

To insure the best possible adhesion, the Contractor shall install the compound in a melted state at a minimum temperature of three hundred seventy-five (375) degrees Fahrenheit. The material shall not scorch or discolor if kept at temperatures between three hundred eighty (380) degrees Fahrenheit to four hundred fifty (450) degrees Fahrenheit for up to four (4) hours.

The Contractor shall disperse the pigmented binder well. The pigmented binder shall be free from skins, dirt, foreign objects, or such ingredients as will cause bleeding, staining, or discoloration.

After application and proper drying time the material shall show no appreciable deformation or discoloration under local traffic conditions, and in an air and/or road temperature ranging from zero (0) to one hundred twenty (120) degrees Fahrenheit.

The contract shall define "drying time" as the minimum elapsed *| time, after application, when the stripe shall have and retain the characteristics required by the preceding sections. Also, the Contractor *| shall establish the drying time by the minimum elapsed time after *| application, after which normal local traffic will leave no impression or imprint on the applied marking.

The drying time shall not exceed a characteristic straight line curve. The lower limits are two (2) minutes at fifty (50) degrees *| Fahrenheit. The upper limits are fifteen (15) minutes at ninety (90) *| degrees Fahrenheit. Both temperatures are at a maximum relative *| humidity of seventy (70) percent.

The stripe shall maintain its original dimensions and placement. The exposed surface shall be free from tack. Cold ductility of the material shall permit normal movement with the road surface without | chipping.

The marking shall have a uniform cross section. The Contractor *| shall disperse the pigment evenly throughout the material. The density *| and character of the material shall be uniform throughout its thickness.

The material shall not smear or spread under normal traffic conditions at temperatures below one hundred twenty (120) degrees Fahrenheit.

The filler incorporated with the resins or binders shall be a white calcium carbonate or equivalent filler.

The white thermoplastic shall have a pigment containing more than | six (6) percent Titanium Dioxide and after setting, shall be pure white, free from dirt or tint.

Yellow reflectorized thermoplastic compound shall be "Federal
--Yellow".

The binder includes a mixture of non-drying synthetic resins. At *| least one (1) resin is solid at room temperature. The total binder | content of the thermoplastic compound shall be more than fifteen (15) | percent and less than thirty-five (35) percent by weight.

The material shall not change in its color and brightness characteristics after prolonged exposure to sunlight.

The manufacturer shall mix reflectorizing beads into the material *| of more than twenty (20) percent and less than fifty (50) percent by *| weight of the material. The Contractor shall apply the beads that the *| Contractor applies to the surface of the material automatically at a *| uniform rate of about three (3) pounds of glass beads to every one hundred (100) square feet of line.

- The glass beads used in the formulation shall: *|
- (1) have a refractive index of more than 1.51 when tested by the liquid immersion method at twenty-five (25) degrees Celsius; *|
 - (2) include seventy (70) percent minimum by count of true spheres; *|
 - (3) be free from air inclusions; and *|
 - (4) have the following gradation: *|

U. S. Sieve Number	Percent Passing
30	90 - 100
40	35 - 100
100	0 - 10

More than seventy (70) percent of the spheres shall conform to the following requirements: *|

- (1) The surface of the spheres shall be smooth, lustrous, and free from film scratch and pits.
- (2) The spheres shall be clear and transparent and shall not deviate in shape or fused spheroids.
- (3) The spheres shall show high autocollimating efficiency. Less than one (1) percent shall be black, amber, or milky. |

- The glass beads dropped on the applied marking shall: *|
- (1) have a refractive index of more than 1.51 when tested by the liquid immersion method of twenty-five (25) degrees Celsius; *|
 - (2) include seventy (70) percent minimum by count of true spheres; *|
 - (3) be free from air inclusion; and *|
 - (4) have the following gradation: *|

U. S. Sieve Number	Percent Passing
20	90 - 100
80	0 - 10

More than seventy (70) percent of the spheres shall conform to the following requirements:

- (1) The surface of the spheres shall be smooth, lustrous, and free from film scratch and pits.
- (2) The spheres shall be clear and transparent and shall not deviate in shape or fused spheroids.
- (3) The spheres shall show high autocollimating efficiency. Less than one (1) percent shall be black, amber, or milky.

(B) Specifications and Tests

(1) Color.

(a) **White.** Initially white; as demonstrated by a standard color difference meter such as the Gardner Color Difference Meter manufactured by Gardner Laboratories, Inc., Bethesda, Maryland. The material shall show deviations from a magnesium oxide standard less than the following:

Scale Definition	Magnesium Oxide Standardized Sample	
	Rd Reflectance	100
a Redness-Greenness	0	-5 to +5
b Yellowness-Blueness	0	-10 to +10

(b) **Yellow.** Initially yellow; equal to standard color chips using Federal test method standard 141 Method 4252.

- (2) **Water Absorption.** Material shall have less than 0.5 percent by weight of retained water when tested by ASTM D 570, procedure (a).
- (3) **Softening Point.** Material shall have a softening point of more than ninety (90) degrees Celsius according to ASTM E 28.
- (4) **Specific Gravity.** Specific gravity of compound at twenty-five (25) degrees Celsius shall be from 1.9 to 2.5.
- (5) **Impact Resistance.** The impact resistance shall be more than fifteen (15) inch-pounds at seventy-seven (77) degrees Fahrenheit after the Contractor:
 - (a) heats the material for four (4) hours at four hundred (400) degrees Fahrenheit,

(b) casts the material into bars of one (1) inch cross sectional area and three (3) inches long and *

(c) places the material with one (1) inch extending above the vise in a cantilever beam (Izod Type) tester using the twenty-five (25) inch pound scale. The Contractor shall see ASTM D 256 for description of this instrument. *

(6) **Bond Strength.** If the Contractor cements two (2) concrete blocks two (2) inches by three (3) inches by seven (7) inches together on the three (3) inch by seven (7) inch faces with a one-sixteenth (1/16) to one-eighth (1/8) inch layer of the thermoplastic traffic line material and tested according to ASTM C 321, the bond strength shall be more than one hundred fifty (150) pounds square inch. *

(7) **Indentation Resistance.** According to ASTM D 2240, the reading of the Shore Durometer, Type A, after fifteen (15) seconds, shall be more than the amounts designated when the Contractor tests the material after heating for four (4) hours at four hundred (400) degrees Fahrenheit and cooling to the following temperatures: *

Temperature	Reading
115°F.	65
77°F.	95
40°F.	95

(C) **Packaging.** The Contractor shall mark each unit container clearly and adequately to show the color of the material, the process batch number or similar manufacturer's identification, the manufacturer's name and location of plant, and the date of manufacture. *

The Contractor shall deliver the material to a designated area in unit containers as processed by the manufacturer. Each unit container when filled shall weigh more than twenty-four (24) pounds and less than fifty-two (52) pounds. *

(D) **Warranty.** The Contractor shall guarantee the thermoplastic compound pavement marking material furnished and installed under this contract against failure due to poor adhesion resulting from defective materials or methods of application. *

For accepted pavements carrying thirty thousand (30,000) vehicles per day or less, the Contractor shall replace that portion of the pavement markings at no cost to the State that has not performed according to the following: *

1. Crosswalks and stop lines:

Ninety (90) percent of the total of any one (1) intersection for one (1) year.

Seventy-five (75) percent of the total of any one (1) intersection for two (2) years.

Fifty (50) percent of the total of any one (1) intersection for less than three (3) years.

2. Lane Lines, Edge Lines, and Center Lines:

Ninety (90) percent of a unit for one (1) year.

Eighty (80) percent of a unit for two (2) years.

Sixty (60) percent of a unit for three (3) years.

(A "Unit" is defined as any length of highway having installed thereon 2,000 lineal feet of line of specified width in any combination or pattern.)

The replacement material installed under this guarantee shall be guaranteed the same as the original material, from the date of the original installation.

712.56 Waterproof Connectors for Highway Lighting. The Contractor shall *| provide waterproof molded rubber connector kits accepted by the Engineer *| where shown in the contract. Connector shall be six hundred (600) volt, quick disconnect, in-line connectors, fused for ungrounded conductor and non-fused for neutral at each pole. Opening in connectors for line conductors shall be suitable for cables furnished. Lubrication and taping shall be as recommended by the manufacturer of the connectors. The fused connectors shall accommodate standard midget, ferrule-type fuses of the capacity indicated.

712.57 Hot Applied Rubberized Sealant. Hot applied rubberized sealant shall be flexible and suitable to seal inductive wire loops imbedded in asphalt concrete and portland cement concrete pavements for traffic signal work and vehicle counters. The sealant shall be non-tracking under traffic. At application temperatures, the sealant shall be a thin, free-flowing fluid that penetrates saw cuts and self-levels to permit uniform applications. The Contractor shall melt and apply the sealant to pavements using a pressurized *| application unit. The sealant shall be relatively stiff but shall remain flexible at low pavement surface temperatures. Test results shall conform to the following:

TESTS	SPECIFICATIONS
Penetration, 77 degrees Fahrenheit	25 - 35 maximum
Flow, 140 degrees Fahrenheit	0 mm - 5 mm maximum
Resilience, 77 degrees Fahrenheit	40 percent minimum
Softening Point	180 deg. F. min.
Ductility, 77 degrees Fahrenheit	30 cm minimum
Mandrel Bend, 0 degrees Fahrenheit, 180 degrees 5s, 1/2 inch diameter	
Rec. Pour Temperature	380 degrees Fahrenheit
Safe Heating Temperature	410 degrees Fahrenheit
375 degrees Fahrenheit Viscosity	30 poise
Unit Weight	10.0 pounds/gallon
Coverage, 1/2 inch x 1/2 inch crack	13.0 pounds per 100 foot