



INVITATION FOR SEALED BID

TAC 267A

Description: Reflective Sheeting

Department: PUBLIC WORKS

NIGP Commodity Code(s): 550-44-00-00-000-0

Total pages including this page is 45

Important Instruction – Read Carefully:

If you have obtained these bid specifications from either of:

City of Tulsa's Fax-on-Demand (918-596-1171) or

City of Tulsa's Web-site : www.cityoftulsapurchasing.org

you must notify the buyer Darlene Donica of your intent to bid by e-mail ddonica@ci.tulsa.ok.us in order to receive addenda. The buyer will always acknowledge your e-mail for your records. All addenda will be posted on fax-on-demand and the web-site.

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Pay special attention to those pages with a reference to the following notes:

Note #1: Signature of authorized agent required

Note #2: Signature of an authorized agent and notarized required

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Your bid response should follow the same format listed above plus any additional format requested in the body of the bid invitation.

**INVITATION FOR SEALED BIDS
TO
City of Tulsa**

200 CIVIC CENTER, ROOM 109, TULSA, OKLAHOMA 74103

Bid number and date of bid opening must appear on the lower
left outside corner of bid envelopes and all related containers.

DATE OF OPENING: May 16, 2002

BID NUMBER: TAC 267A

BID MUST BE IN THE CITY CLERK'S OFFICE AT THE ABOVE ADDRESS BY 5:00 P.M. THE DAY PRECEDING THE "DATE OF OPENING" SHOWN ABOVE.

BIDS WILL BE OPENED AT 8:30 A.M. IN THE CITY COUNCIL ROOM ON THE DAY SPECIFIED UNDER "DATE OF OPENING."

PUBLISHED IN THE TULSA DAILY COMMERCE AND LEGAL NEWS: May 8, 2002

Bid must be accompanied by bidder's bond, cashier's check or certified check in the amount of: \$5,000.00

PLEASE READ TERMS AND CONDITIONS ON THE NEXT PAGE BEFORE COMPLETING BID DOCUMENTS

DARLENE DONICA 918-596-7558

THE FOLLOWING SECTION MUST BE COMPLETED BY BIDDER

Delivery will be made in not more than _____ days after receipt of order.

Payment terms _____ % _____ days.

City of Tulsa may increase quantity of order at the unit price bid for _____ days. (Bidder to Specify Days)
I have examined the terms and specifications and the instructions to bidders herein and agree, provided I am awarded a contract, to provide the above described items for the sum shown in accordance with the terms and specifications stated herein. All deviations are in writing and attached hereto.

Enclosed is a BID BOND ; CASHIER'S CHECK; Certified Check in the amount of \$ _____, which I agree the City of Tulsa may retain as liquidated damages in the event of my failure to comply with the terms of this bid.

MUST BE SIGNED BY AUTHORIZED AGENT TO BE VALID

FIRM NAME _____ by _____
(Signature)

STREET _____ TITLE _____

CITY STATE _____ ZIP CODE _____ PHONE NUMBER _____ DATE _____

GENERAL TERMS AND CONDITIONS OF BIDS

THESE ITEMS APPLY TO AND BECOME A PART OF THE BID.

NO EXCEPTIONS TO THESE TERMS & CONDITIONS WILL BE CONSIDERED.

1. **BIDS MUST BE SUBMITTED ON THIS FORM ONLY INCLUDING A SIGNATURE OF AN AUTHORIZED AGENT.** Each bid shall be placed in a separate envelope. Be sure envelope is completely and properly identified and sealed, showing the bid number and date in the lower left hand corner. Bids must be time stamped in the office of the City Clerk by 5:00 P.M. on the day before date of opening.
2. No bidder may withdraw his proposal for a period of thirty (30) days after the date and hour set for the opening of bids.
3. All prices shall be quoted F.O.B. Tulsa, Oklahoma, and delivery to City of Tulsa location shall be without additional charge.
4. The bidder shall attach the manufacturer's name of the equipment or material to be furnished, type, model numbers, manufacturer's descriptive bulletins and specifications. All guarantees and warranties should be clearly stated. This data shall be in sufficient detail to describe accurately the equipment or material to be furnished. Manufacturer's specifications, in respect to the successful bidder, shall be considered as part of his contract with the City of Tulsa.
5. The bidder shall show in the proposal both the unit prices and total amount, where required, of each item listed. In the event of error or discrepancy in the mathematics, the unit prices shall prevail.
6. Any exceptions or deviations from written specifications shall be shown in writing and attached to the bid form.
7. Each bidder agrees to comply with the terms of Title 5, Chapter 1, of Tulsa, Oklahoma Charter and revised ordinances relating to equal employment opportunity.
8. **THE ENCLOSED FORMS REGARDING NON-COLLUSION AND FINANCIAL INTEREST MUST BE SIGNED, NOTARIZED, AND RETURNED WITH THE BID.**
9. The City of Tulsa reserves the right to reject any and all bids, to waive any technicalities in the bidding, and to award each item to different bidders or all items to a single bidder.
10. All bids must be accompanied by bidders bond, cash, certified or cashier's check in the amount shown on the face of the bid form. This amount shall be retained by the City of Tulsa as liquidated damages in the event the successful bidder (or bidders) fails to execute a contract, if required. The bidder agrees that said amount is presumed to be the damages sustained by the City due to the impracticability and extreme difficulty in fixing the actual damages. The office of the City Clerk will return the bid deposits to the unsuccessful bidders, after a contract has been awarded or all bids have been rejected.
11. In the event cash discounts are offered by the bidder, the discount date shall begin with the date of invoice, the date of receipt of all material covered by the purchase order, or the date of receipt by the City of Tulsa of the original copy of the purchase order with properly executed Affidavit of Claimant, whichever is the later date.
12. Direct purchase of certain items of equipment or material by the City of Tulsa are exempt from Federal Excise Tax and Oklahoma Sales Tax. In such cases the bidder shall quote prices which do not include Federal Excise Tax and Oklahoma Sales Tax. The City of Tulsa will furnish executed exemption certificates upon presentation by the bidder at the time of purchase.
13. Bid must show number of days required for delivery under normal conditions. Failure to state delivery time obligates bidder to complete delivery in fourteen (14) calendar days. Unrealistically short or long delivery promises may cause bid to be disregarded. Contractor must keep Purchasing Department advised at all times of status of order. Default in promised delivery or failure to meet specifications authorizes the Purchasing Agent to purchase supplies elsewhere and charge full increase of cost and handling to defaulting contractor. Consistent failure to meet delivery promises without valid reason may cause removal from bid list.
14. Bidder agrees to defend and save City of Tulsa from and against all demands, claims, suits, costs, expenses, damages and judgments based upon infringement of any patent relating to goods specified in this order or the ordinary use or operation of such goods by City or use or operation of such goods in accordance with bidders direction.
15. If the bid requires a written contract, the successful bidder shall execute a written contract with the City of Tulsa and return the required bonds and insurance certificates within ten (10) days after submission of contracts to said bidder by the City.

BIDDER AFFIDAVIT - TITLE 74 O.S. (1974 SUPP.) 85.22-85.25

STATE OF _____ COUNTY OF _____

_____, of lawful age, being first duly sworn on oath says

Authorized Agent

1. (s)he is the duly authorized agent of _____, the bidder submitting the competitive bid which is attached to this statement, for the purpose of certifying the facts pertaining to the existence of collusion among bidders and between bidders and municipal officials or employees, as well as facts pertaining to the giving or offering of things of value to government personnel in return for special consideration in the letting of any contract pursuant to the bid to which this statement is attached.
2. (s)he is fully aware of the facts and circumstances surrounding the making of the bid to which this statement is attached and has been personally and directly involved in the proceedings leading to the submission of such bid; and
3. neither the bidder nor anyone subject to the bidder's direction or control has been a party;
 - a. to any collusion among bidders in restraint of freedom of competition by agreement to bid at a fixed price or to refrain from bidding,
 - b. to any collusion with any municipal official or employee as to quantity, quality or price in the prospective contract, or as to any other terms of such prospective contract, nor
 - c. in any discussions between bidders and any municipal official concerning exchange of money or other thing of value for special consideration in the letting of a contract.

SIGNATURE OF AUTHORIZED AGENT

Subscribed and sworn to before me this _____ day of _____, 20_____.

Signature of Notary Public

MY COMMISSION EXPIRES

The Bidder Affidavit must be completed, signed by an authorized agent, and notarized.

CONTRACTOR/BIDDER INFORMATION SHEET

**To be completed by all Bidders
For Contracts with the City of Tulsa
(Please print or type)**

Project No. or Description _____

Full Name of Bidder _____

Legal Identity
(Corporation, Partnership,
Individual, etc.) _____

Address _____

Telephone No. _____

FAX No. _____

Taxpayer Identification Number _____

Contact Person _____

Phone No. _____

Fax No. _____

E-mail address _____

Web-page Address _____

Price Sheet Summary

Vendor Name: _____ Signature: _____ Date: _____

You will be able to obtain a copy of the Bid Summary on the City of Tulsa's Purchase-Net Fax-on-Demand and Website shortly after bid opening.

TAC 267A

1. Reflective Sheeting, Type I, Engineering Grade, Enclosed Lens, Pressure Sensitive Adhesive (Colors: White, Yellow, Red, Blue, Green, Orange, Brown) \$_____ Per Sq. Ft.
2. Reflective Sheeting, Type II-A, Super Engineer Grade, Enclosed Lens, Pressure Sensitive Adhesive (Colors: White, Yellow, Red, Blue, Green, Orange, Brown) \$_____ Per Sq. Ft.
3. Reflective Sheeting, Type III, Encapsulated Lens High Intensity Grade, Pressure Sensitive Adhesive (Colors: Red, Green, Brown, Silver, Yellow, Blue, Orange) \$_____ Per Sq. Ft.
4. Reflective Sheeting, Type IX, Visual Impact Prismatic Performance Diamond Grade, Pressure Sensitive Adhesive (Colors: White, Yellow, Red, Blue, Green) \$_____ Per Sq. Ft.
5. Reflective Sheeting, Type IV-A, Visual Impact Performance Diamond Grade, Pressure Sensitive Adhesive (Florescent Colors: Yellow, Green, Orange, Yellow) \$_____ Per Sq. Ft.
6. Removable Reflective Sheeting for Vehicle Markings with Controltac Adhesive (3M Series 680) (Colors: White, Gold, Yellow, Light Blue, Lemon Yellow, Ruby Red, "C" Black) \$_____ Per Sq. Ft.
7. Flexible Reflective Sheeting for Vehicle Markings with Controltac Adhesive (3M Series 680) (Colors: White, Orange, Gold, Yellow, Light Blue, Lemon Yellow, Ruby Red, "C" Black) \$_____ Per Sq. Ft.
8. Non-Reflective Vinyl Plastic Sheeting, Pressure Sensitive Adhesive (Color: Black, White) \$_____ Per Sq. Ft.
9. Electronically Cuttable Acrylic Transparent Film for use on Reflective Sheeting, Pressure Sensitive Adhesive (Colors: Yellow, Red, Orange, Blue, Violet, Clear, Green, Brown, Opaque Black) (3M Series 1170) \$_____ Per Sq. Ft.

- 10. Transfer Tape (3M TPM-5) for Electronically Cuttable Film \$_____ Per Sq. Ft.
- 11. Transfer Tape (3M SCPM-2 or 3) \$_____ Per Sq. Ft.
- 12. Vehicle Conspicuity Diamond Grade Sheeting (3M Series 980) with Pressure Sensitive Adhesive (Colors: Red/White, Orange/White, Blue/White) \$_____ Per Sq. Ft.
- 13. Protective Overlay Film (3M Series 1160) \$_____ Per Sq. Ft.

SPECIAL CONDITIONS

1. Length of contract shall be for one (1) full year.
2. City of Tulsa reserves the right to cancel this agreement upon thirty (30) days written notice with good cause.
3. Purchase Orders will be issued on an as needed basis.
4. City of Tulsa reserves the right to require samples on any item prior to bid award.
5. City of Tulsa requires bidder to disclose the manufacturer of each product offered as well as the address of manufacturer's producing facility allowing a "tour" for account of their production capability.
6. City of Tulsa reserves the right, prior to any award, to require upon its request a list of users of the exact retro-reflective sheeting as herein offered. City of Tulsa may contact these users to determine quality level and performance of the offered sheeting. Such information may be considered in the evaluation of the bid.
7. This bid will be awarded by lowest complete category. However, if the City of Tulsa receives incomplete bids from all vendors on any given category, the City of Tulsa reserves the right to:
 - reject all bids for this category,
 - award by individual line in this category, or
 - award category to the most complete and responsive bid.
8. The unit price for each bid item shall be shown in dollars per square foot and shall be applicable to both rolled and pre-cut sheeting.

For this bid to be valid all categories must be totaled and all prices extended.

City of Tulsa would like the option to renew this agreement annually for an additional four years upon completion of initial year.

GENERAL SPECIFICATIONS:

SCOPE: These specifications provide for the furnishing and delivery of various quantities, types and sizes of reflective materials; as detailed herein, to City of Tulsa for the period indicated. The sheeting shall be part of a family of matched component products required for the manufacture and imaging of permanent traffic control signs as described under MATCHED COMPONENT SYSTEM.

TERM OF AGREEMENT: The term of this agreement shall be for a one (1) year period with the option to renew annually for four years upon completion of the initial year. During this period of time, orders will be issued for materials as needed. It is emphasized that City of Tulsa does not guarantee to purchase any specific quantity of any item listed, during the period of this agreement. Final acceptance or rejection of any or all materials received will be determined by City of Tulsa.

TERMINATION OF AGREEMENT: This contract may be terminated by City of Tulsa at its option, upon thirty (30) days notice in writing. if the materials furnished do not conform to the standards set forth herein and on the attached Bid Form; or if the deliveries and servicing of this contract do not conform to the requirements detailed herein.

PRE-QUALIFICATION: Materials (sheeting, process inks, overlay films) shall be considered for use only when, in the opinion of the agency, sufficient evidence exists to ensure that the materials and services offered can reliably conform to this specification. The sheeting manufacturer shall provide evidence of performance and suitability for use in accordance with the Agency's Qualified Products Procedures.

A. Pre-qualification

All prospective bidders are hereby notified that the material (sheeting, process inks, overlay films) proposed for submission or for use in production of finished traffic control devices shall be a material of manufacture and product code or designation shown on the list of approved manufacturers of materials covered by this specification maintained by the Agency.

Prospective bidders or suppliers who wish to establish a performance history and pre-qualification for materials (sheeting, process inks, overlay films) governed by this specification should contact the agency for instructions on samples and information required for testing.

B. Performance History

The sheeting manufacturer shall provide test data showing that representative combined production material (sheeting, process inks, overlay films) of the type to be supplied has met the requirements for 36 months of accelerated outdoor weathering described in section 6.10.

This data shall be gathered by states own testing facility in accordance with ASTM D 4956 or an independent agency, such as AASHTO's National Transportation Product Evaluation Program (NTPEP).

The data submitted shall cover both the retro-reflective sheeting and process inks and/or overlay films manufactured by the sheeting manufacturer in standard traffic colors. The process inks and overlay films shall be tested with the sheeting to which they are intended to be applied. The data collection shall have been completed no more than 5 years prior to the offer.

The materials may also be considered for qualification if, in the opinion of the engineer, sheeting material of the type to be supplied has been used successfully in a substantial signing program in similar climatic conditions for a least 5 years.

To be considered an equal alternate to an existing, qualified product, a candidate product must be used or weathered along side the control or benchmark material to eliminate any bias in the exposure procedures.

BIDDING AND AWARD: Bids shall be submitted in duplicate, only on the Bid Form attached.

City of Tulsa reserves the right to make an award on the basis of individual group, combination of groups, or overall best bid for all groups, as it is deemed best interest the City of Tulsa will be served. Notice of award will be made in writing to the successful bidder (s).

DELIVERY: Successful bidder will be expected to make delivery within a maximum of thirty (30) calendar days, after receipt of any individual order, during the term of the agreement. Deliveries made without such order shall be at the bidder's risk and shall leave the City of Tulsa the option of canceling any contract implied or expressed herein. Deliveries shall be made primarily to City of Tulsa and other departments and locations as needed. Each bidder shall show a delivery schedule in the bid proposal.

INVOICING: All invoices shall be submitted to City of Tulsa. Itemized as to quantity, description, and the net unit price. In addition, invoices must show the names of Department and Division or City of Tulsa Purchase Order number and originating Division Requisition number.

MANUFACTURER SERVICES:

The successful bidder(s) shall provide the following services for City of Tulsa:

- A. Provide manufacturer certification that all materials meet specifications set forth.
- B. Provide formal and informal training with review classes approximately every six (6) months or when requested by City of Tulsa. Training will cover subjects listed below:
 - 1. Fabrication - Application Procedures
 - 2. Color Processing
 - 3. Equipment Use and Maintenance
 - 4. Corrective and Preventative Maintenance Procedures
 - 5. Materials Technology and Use
- C. Act as an ongoing source of information and professional help in maintaining the fabrication program.
- D. The bidder shall furnish at no additional cost to City of Tulsa the process inks, clears, and thinners for the different types of traffic signs (black, red, green, etc.) recommended for their sheeting to meet the performance life requirements of this specification if more than one type of ink is available per sheeting type City of Tulsa will choose which ink to use. Special mixed inks shall also be included at no additional cost to City of Tulsa.
- E. The bidder shall furnish at no additional cost to City of Tulsa the slip sheeting recommended by the sheeting manufacturer for sheeting surface protection during manufacturing and transportation of traffic signs. Slip sheeting shall come in rolls or sheets as requested by City of Tulsa in at least equal square footage and in the same widths as the sheeting supplied.
- F. Washers recommended by the sheeting manufacturer to protect the sign surface from damage by bolts or other fasteners shall be furnished by the bidder at no additional cost to City of Tulsa.
- G. The bidder shall furnish at no additional cost to the City of Tulsa the different types of sheeting in pre-cut sheets as specified by City of Tulsa. Sheeting should be packed twenty-five (25) sheets per package.
- H. If specified at the time of the order by City of Tulsa, all types of 15" or 30" wide material shall have sprocket holes along the full length of each edge, to fit the material transport mechanism of existing City of Tulsa sign shop type of model plotters. All types of sheets shall be cut square when requested.

MATCHED COMPONENT SYSTEM: Suppliers of reflective sheeting shall bid on a complete category. The category will include the sheeting and ink or film that will be applied to the sheeting. The inks, and films which are compatible with the sheetings and when used in accordance with the sheeting manufacturer's instructions shall not lessen the warranty term as described in section 7.0 (Performance Requirements and Obligations).

CITY OF TULSA SPECIFICATION RETRO-REFLECTIVE SHEETING FOR TYPES I, III, & IX

NOTICE: This specification contains a sheeting manufacturer's field performance obligation paragraph 7.2 which shall apply only when included and made part of a bid request, proposal, and/or purchase agreement.

1.0 Scope

This specification covers flexible white or colored, wide angle retro-reflective sheeting (hereinafter called sheeting), tape and related processing materials designed to enhance nighttime visibility of traffic control signs and objects. The sheeting types shall consist of an enclosed glass bead lens, encapsulated glass bead elements, and prismatic lens elements. The enclosed glass bead lens and the encapsulated glass bead type of sheeting are to adhere to a synthetic resin and encapsulated by a flexible transparent plastic that has a smooth outer surface. The prismatic sheeting shall consist of prismatic lens elements with a distinctive interlocking diamond seal pattern and datum orientation marks visible from the face of a smooth surface. The sheeting shall have a pre-coated adhesive protected by an easily removable liner.

The sheeting shall be part of a family of matched component products required for the manufacture and imaging of permanent traffic control signs as described in section 4. Only section 2.0, section 6.2.4 and section 7.2.1 cover printed colored areas of signs.

BID GUARANTEE

Each bid must be accompanied by a **\$5,000.00 bid bond** unless the bidder has an "annual bond" on file prior to the closing date of this bid. A corporate officer of the sheeting manufacturer must sign any bid submitted.

PERFORMANCE BOND

The successful bidder will be required to furnish a performance bond in an amount equal to the projected first year contract value. In no event will this bond be less than **\$1,000,000 (one million dollars)**, guaranteeing the agency to the faithful performance of the contract against any act of omission or commission by the successful bidder contrary to the terms of the contract.

PRODUCT BOND

If the sheeting manufacturer's materials have not been successfully employed within the agency's signing program for the full warranty period, the supplier shall post a product bond against which the agency may invoke the warranty provisions should the product fail. The bond shall be posted for an amount of time equal to the sheeting warranted performance life required by this specification. The bond shall be in an amount equal to the maximum warranty penalties allowed on the volume of materials estimated for purchase. Should actual purchases during the contract period exceed the amounts estimated, the vendor will be required to increase the bond to cover the additional liability.

2.0 Pre-qualification and Performance History

Materials (sheeting, process inks, overlay films) shall be considered for use only when, in the opinion of the agency, sufficient evidence exists to ensure that the materials and services offered can reliably conform to this specification. The sheeting manufacturer shall provide evidence of performance and suitability for use in accordance with the Agency's Qualified Products Procedures.

2.1 Pre-qualification

All prospective bidders are hereby notified that the material (sheeting, process inks, overlay films) proposed for submission or for use in production of finished traffic control devices shall be a material of manufacture and product code or designation shown on the list of approved manufacturers of materials covered by this specification maintained by the Agency.

Prospective bidders or suppliers who wish to establish a performance history and pre-qualification for materials (sheeting, process inks, overlay films) governed by this specification should contact the agency for instructions on samples and information required for testing.

2.2 Performance History

The sheeting manufacturer shall provide accelerated outdoor weathering test data described in section 6.9 showing that representative combined production material (sheeting, process inks, overlay films) of the type to be supplied has met the requirements of 36 months for encapsulated lens and prismatic lens sheeting and 24 months for enclosed lens sheeting.

This data shall be gathered by states own testing facility in accordance with ASTM D 4956 or an independent agency, such as AASHTO's National Transportation Product Evaluation Program (NTPEP).

The data submitted shall cover both the retro-reflective sheeting and process inks and/or overlay films manufactured by the sheeting manufacturer in standard traffic colors. The process inks and overlay films shall be tested with the sheeting to which they are intended to be applied. The data collection shall have been completed no more than 5 years prior to the offer.

The materials may also be considered for qualification if, in the opinion of the engineer, sheeting material of the type to be supplied has been used successfully in a substantial signing program in similar climatic conditions for a least 5 years.

To be considered an equal alternate to an existing, qualified product, a candidate product must be used or weathered along side the control or benchmark material to eliminate any bias in the exposure procedures.

3.0 Classification and Conformance

The sheeting shall conform to FP-96, AASHTO M 268 and ASTM D 4956 adhesive class 1 or 2 Type 1 (enclosed glass beads lens), Type III (encapsulated glass bead elements) and shall further be required by the plans or in the invitation to bid to conform to one of the following types:

3.1 Type A Sheeting

Type A sheeting is intended for shop production of new stationary traffic control signs or objects, exclusive of those used for construction and maintenance work zones.

3.1.1 The sheeting shall have either a pre-coated pressure sensitive adhesive (Class 1) or a tack-free adhesive (Class 2) activated by heat (enclosed lens and encapsulated lens) applied in a heat vacuum applicator in a manner recommended by the sheeting manufacturer. Both adhesive classes shall be protected by an easily removable liner.

3.2 Type B Sheeting (enclosed lens and encapsulated lens)

Type B sheeting is intended for use on stationary traffic control signs and objects; it is Type A sheeting, pre-punched for use in electronic cutting devices.

3.2.1 The sheeting shall have a pre-coated pressure sensitive adhesive (Class 1).

4.0 Items to be Included in Bids.

4.1 Process Inks

4.1.1 The manufacturer of the sheeting being offered shall furnish at no additional cost the process inks in standard traffic colors, clears and thinners recommended for the sheeting to meet the performance requirements of this specification. The sheeting manufacturer shall further be responsible for technical assistance in the use of these inks in accordance with Section 8, below.

4.1.2 The process colors shall be a single line of traffic colors which: may be applied before and after sheeting is applied to a substrate; require no component premixing; and will air dry for packing in 3 hours or less and requires no clear coating.

4.1.3 The process colors specific to enclosed lens sheeting shall air dry 2 hours between colors and 3 hours before packaging. It shall oven dry 30 minutes @ 150 degrees F between colors and oven dry 30 minutes @ 150 degrees F before packaging. It shall be a one part ink with no clear coating or edge sealer required. It shall provide the same effective field performance as the sheeting on which it is applied.

4.1.4 The sheeting manufacturer shall, upon request, provide custom color match formulas from the ink series within 7 days at no charge to the agency.

4.2 Slip Sheet. Slip sheet paper recommended by the sheeting manufacturer for surface protection during heat vacuum application or for use in packaging, storing or shipping shall be furnished at no additional charge. Slip sheet paper shall be supplied in rolls by the manufacturer, in at least equal square footage and in the same widths as the sheeting supplied.

4.3 Temperature Indicators: The manufacturer at no additional charge shall furnish expendable temperature indicators recommended by the sheeting manufacturer for control and calibration of proper application temperature.

4.4 Washers: Washers recommended by the sheeting manufacturer to protect the sign surface from damage by bolts or other fasteners shall be furnished by the manufacturer at no additional charge.

4.5 Overlay Films. The sheeting manufacturer shall also manufacture colored acrylic imaging films and clear protective overlays, which are compatible with the sheetings, and when used in accordance with the sheeting manufacturer's instructions, shall not lessen the warranty term as described in section 7.2.

4.6 Manuals. The sheeting manufacturer shall submit with their proposal 4 each complete "Production Manuals" of the manufacturer's traffic sign production and instruction manuals which detail all pertinent information as to the fabrication, preparation of substrate, approved application equipment, silk screening, drying, packaging, storage, handling, installation, field cleaning methods, cleansers and solutions recommended, cleaning systems approved for use, and a listing of the inks, and thinners they will be supplying with all sheeting.

5.0 Test Panels and Test Conditions

Unless otherwise specified herein, sheeting shall be supplied to test panels in accordance with ASTM D 4956 section 8.2 and test conditions shall conform to ASTM D 4956 section 8.1.

6.0 Requirements

6.1 Color Requirements. Color shall be as specified and shall conform to the requirements of Table I. Conformance to color requirements shall be determined spectrophotometrically in accordance with ASTM E 1164, with instruments utilizing either 45/0, or 0/45 illumination/viewing conditions and tolerances as described in ASTM E 1164 for retro-reflective materials. CIE Tristimulus values for the 2° observer and illuminant D65 shall be calculated in accordance with ASTM E 308. The standards for calibrating the test instruments shall be the MUNSELL PAPERS listed in Table I which have been recently calibrated on a spectrophotometer.

Table I (enclosed lens)

| Color | Color Specification Limits* and Reference Standards | | | | | | | | Reflectance Limit (y) | | Munsell Paper** |
|--------|---|----------|----------|----------|----------|----------|----------|----------|-----------------------|------|-----------------|
| | <u>x</u> | <u>y</u> | <u>X</u> | <u>Y</u> | <u>x</u> | <u>y</u> | <u>x</u> | <u>y</u> | Min. | Max. | |
| | White | .303 | .300 | .368 | .366 | .340 | .393 | .274 | .329 | 27.0 | |
| Yellow | .498 | .412 | .557 | .442 | .479 | .520 | .438 | .472 | 15.0 | 40.0 | 1.25Y 6/12 |
| Red | .613 | .297 | .708 | .292 | .636 | .364 | .558 | .352 | 2.5 | 11.0 | 7.5r 3/12 |
| Blue | .066 | .216 | .190 | .255 | .244 | .210 | .144 | .038 | 1.0 | 10.0 | 5.8PB 1.32/6.8 |
| Brown | .445 | .353 | .604 | .396 | .556 | .443 | .445 | .386 | 3.0 | 9.0 | 5YR 3/6 |
| Green | .030 | .398 | .166 | .364 | .286 | .446 | .201 | .794 | 3.0 | 8.0 | IOG 3/8 |

Table I (encapsulated lens)

| Color | Color Specification Limits* and Reference Standards | | | | | | | | Reflectance Limit (y) | | Munsell Paper** |
|--------|---|----------|----------|----------|----------|----------|----------|----------|-----------------------|------|-----------------|
| | <u>x</u> | <u>y</u> | <u>x</u> | <u>Y</u> | <u>x</u> | <u>y</u> | <u>x</u> | <u>y</u> | Min. | Max. | |
| | White | .303 | .300 | .368 | .366 | .340 | .393 | .274 | .329 | 27.0 | |
| Yellow | .498 | .412 | .557 | .442 | .479 | .520 | .438 | .472 | 15.0 | 40.0 | 1.25Y 6/12 |
| Red | .613 | .297 | .708 | .292 | .636 | .364 | .558 | .352 | 2.5 | 11.0 | 7.5r 3/12 |
| Blue | .066 | .216 | .190 | .255 | .244 | .210 | .144 | .038 | 1.0 | 10.0 | 5.8PB 1.32/6.8 |
| Brown | .445 | .353 | .604 | .396 | .556 | .443 | .445 | .386 | 3.0 | 9.0 | 5YR 3/6 |
| Green | .030 | .398 | .166 | .364 | .286 | .446 | .201 | .794 | 3.0 | 8.0 | IOG 3/8 |

Table I (prismatic lens)

| Color | Color Specification Limits* and Reference Standards | | | | | | | | Reflectance Limit (y) | | Munsell Paper** |
|--------|---|----------|----------|----------|----------|----------|----------|----------|-----------------------|------|-----------------|
| | <u>x</u> | <u>y</u> | <u>x</u> | <u>Y</u> | <u>x</u> | <u>y</u> | <u>x</u> | <u>y</u> | Min. | Max. | |
| | White | .305 | .305 | .355 | .355 | .335 | .375 | .285 | .325 | 40.0 | |
| Yellow | .487 | .423 | .545 | .454 | .465 | .534 | .427 | .483 | 24.0 | 45.0 | 1.25Y 6/12 |
| Red | .690 | .310 | .595 | .315 | .569 | .341 | .655 | .345 | 3 | 15 | 7.5r 3/12 |
| Blue | .078 | .171 | .150 | .220 | .210 | .160 | .137 | .038 | 1.0 | 10.0 | 5.8PB 1.32/6.8 |
| Green | .030 | .398 | .166 | .364 | .286 | .446 | .201 | .794 | 3.0 | 9.0 | IOG 3/8 |

* The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illumination Source D65 - these colors are equivalent to those listed in ASTM D 4956 using Source C.

** Available from Munsell Color Company, 2441 Calvert Street, Baltimore, Maryland

6.2 Coefficient of Retro-reflection: The coefficients of retro-reflection shall be determined in accordance with ASTM E-810, for the minimum requirements of Table II. This table contains "core" values as found in ASTM D 4956, as well as supplemental values at 0.1° and 1.0° observation and 45° entrance to fully characterize sheeting performance throughout its expected range of use.

6.2.1 Units: Coefficients of retro-reflection shall be specified in units of candelas per footcandle per square foot.

6.2.2 The observation angles shall be 0.1°, 0.2°, 0.5°, and 1.0°.

6.2.3 The entrance angles shall be -4°, 30° and 45°.

6.2.4 For screen printed transparent colored areas or transparent colored overlay films on white sheeting, the coefficients of retro-reflection shall not be less than 70% of the values for corresponding color in Table II (Level I, II). For Level III the ratios of the Ra for the white to the Ra for the color, when measured at 0.2° observation, -4° entrance, and 0° rotation, shall be 5:1 to 15:1 for the red, and not less than 5:1 for blue and green.

6.3 Specular Gloss: The retro-reflective sheeting shall have an 85° specular gloss of not less than 40 when tested in accordance with ASTM D 523.

6.4

Table II (enclosed lens)
Minimum Coefficient of Retro-reflection
(cd/lux/m²)

| White | -4.0 | 30.0 | 45.0 |
|-------|------|------|------|
| 0.1 | 75 | 35 | 9 |
| 0.2 | 70 | 30 | 8 |
| 0.5 | 30 | 15 | 7 |
| 1.0 | 12 | 9 | 4 |

| Green | -4.0 | 30.0 | 45.0 |
|-------|------|------|------|
| 0.1 | 10 | 5 | 2 |
| 0.2 | 9 | 3.5 | 1.5 |
| 0.5 | 4.5 | 2.2 | 0.5 |
| 1.0 | 1.8 | 1.6 | 0.4 |

| Yellow | -4.0 | 30.0 | 45.0 |
|--------|------|------|------|
| 0.1 | 53 | 23 | 5 |
| 0.2 | 50 | 22 | 4.5 |
| 0.5 | 25 | 13 | 4 |
| 1.0 | 8.5 | 5.5 | 2 |

| Blue | -4.0 | 30.0 | 45.0 |
|------|------|------|------|
| 0.1 | 4.2 | 2 | 0.8 |
| 0.2 | 4 | 1.7 | 0.6 |
| 0.5 | 2 | 0.8 | 0.5 |
| 1.0 | 0.7 | 0.6 | 0.2 |

| Red | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 15 | 6.2 | 1 |
| 0.2 | 14 | 6 | 0.6 |
| 0.5 | 7.5 | 3 | 0.5 |
| 1.0 | 2.4 | 1 | 0.4 |
| | | | |

| Brown | -4.0 | 30.0 | 45.0 |
|-------|------|------|------|
| 0.1 | 1.1 | 0.5 | 0.3 |
| 0.2 | 1 | 0.3 | 0.2 |
| 0.5 | 0.3 | 0.2 | 0.1 |
| 1.0 | 0.2 | 0.1 | 0.1 |
| | | | |

Table II (encapsulated lens)
Minimum Coefficient of Retro-reflection
(cd/lux/m²)

White

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 300 | 225 | 100 |
| 0.2 | 250 | 175 | 95 |
| 0.5 | 95 | 70 | 55 |
| 1.0 | 10 | 9.5 | 9.0 |

Green

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 54 | 40 | 15 |
| 0.2 | 45 | 30 | 12 |
| 0.5 | 15 | 12 | 10 |
| 1.0 | 1.0 | 0.8 | 0.5 |

Yellow

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 200 | 150 | 60 |
| 0.2 | 170 | 135 | 50 |
| 0.5 | 62 | 60 | 40 |
| 1.0 | 9.0 | 8.5 | 8.0 |

Blue

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 24 | 14 | 7.0 |
| 0.2 | 20 | 11 | 6.0 |
| 0.5 | 7.5 | 5.0 | 4.0 |
| 1.0 | 0.5 | 0.3 | 0.1 |

Red

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 54 | 40 | 15 |
| 0.2 | 45 | 30 | 12 |
| 0.5 | 15 | 12 | 10 |
| 1.0 | 2.0 | 1.5 | 1.0 |

Brown

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 14 | 10 | 3.0 |
| 0.2 | 12 | 8.5 | 2.8 |
| 0.5 | 5.0 | 3.5 | 2.5 |
| 1.0 | 0.5 | 0.3 | 0.1 |

Table II (prismatic lens)
Minimum Coefficient of Retro-reflection
(cd/lux/m²)

White

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 625 | 430 | 120 |
| 0.2 | 370 | 225 | 90 |
| 0.5 | 275 | 125 | 35 |
| 1.0 | 75 | 42 | 10 |

Green

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 80 | 45 | 12.5 |
| 0.2 | 45 | 28 | 9.8 |
| 0.5 | 32 | 16 | 3.5 |
| 1.0 | 9 | 6 | 1.6 |

Yellow

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 565 | 315 | 90 |
| 0.2 | 300 | 180 | 70 |
| 0.5 | 220 | 100 | 27 |
| 1.0 | 58 | 35 | 8.8 |

Blue

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 42 | 22 | 6 |
| 0.2 | 22 | 14 | 4.5 |
| 0.5 | 17 | 8 | 1.5 |
| 1.0 | 4.5 | 3 | .8 |

Red

| | -4.0 | 30.0 | 45.0 |
|-----|------|------|------|
| 0.1 | 165 | 110 | 24 |
| 0.2 | 98 | 65 | 26 |
| 0.5 | 70 | 32 | 10 |
| 1.0 | 20 | 11 | 3 |

- 6.5 Color Processing: The retro-reflective sheeting shall be designed to work in concert with recommended imaging systems. Color processing with compatible transparent and opaque process colors shall be possible in accordance with the sheeting manufacturer's recommendation at temperatures of 60 to 100°F (16 to 38°C) and relative humidity of 20 to 80%. The sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures recommended by the sheeting manufacturer.
- 6.6 Shrinkage: The retro-reflective sheeting shall comply with the shrinkage requirements contained in ASTM D 4956 section 7.6.
- 6.7 Flexibility: The reflective sheeting with the liner removed and conditioned as in 5.1 shall be sufficiently flexible to show no cracking when slowly bent, in one second's time around a 1/8 inch mandrel with adhesive contacting the mandrel. Talcum powder shall be spread on the adhesive to prevent sticking to the mandrel.
- 6.8 Adhesive: The retro-reflective sheeting shall comply with the liner removal and adhesion requirements contained in ASTM D 4956 sections 7.8 and 7.9.
- 6.9 Impact Resistance: The sheeting, applied according to the manufacturer's recommendations to a cleaned, etched aluminum panel of alloy 6061-T6, 0.04" (0.10 cm) by 3" (7.6 cm) by 5" (12.7 cm) and conditioned as in 5.1, shall show no cracking when the face of the panel is subjected to an impact of a 2 inch diameter steel ball (1.19 lbs., 0.54 kg) dropped from a height of 8.5 inches (21.6 cm) through a 2.125 inch (5.4 cm) tube.
- 6.10 Resistance to Accelerated Weathering: The retro-reflective surface of enclosed lens, encapsulated lens and prismatic lens sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing or dimensional change in unprotected outdoor exposure for the following time periods: after two years for enclosed lens, and after three years for encapsulated lens and prismatic lens sheeting. Unprotected outdoor exposure conducted according to ASTM G7 and inclined at 45° from the horizontal facing the equator. After cleaning, the coefficient of retro-reflection shall not be less than 80% for encapsulated lens, 70% for prismatic lens, and 50% for enclosed lens of the values in Table II and the colors shall conform to paragraph 6.10.1.

Following weather exposure, gently wash panels using a soft cloth or sponge and clean water or a dilute solution (1% by weight in water, maximum concentration) of a mild detergent. After washing, rinse thoroughly with clean water and blot dry with a soft clean cloth. After washing and drying, condition the panels at room temperature for at least two hours prior to conducting any property measurements.

- 6.10.1 Shows "good" color fastness or better when tested as in 6.10.
- 6.10.2 Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 1/32 inch (0.08 cm) shrinkage or expansion.
- 6.10.3 Retain not less than 80% for encapsulated lens, 70% for prismatic lens, 50% for enclosed lens of the coefficient of retro-reflection values as specified in Table II.
Retro-reflective performance measurements after weather exposure shall be made at all observation and entrance angles. Prismatic sheeting shall be measured using the average values at 0° & 90° rotation. Where more than one panel of a color is measured, the coefficient of retro-reflection shall be the average of all the determinations.
- 6.10.4 Not to be removable from the aluminum panels without damage.
- 6.11 Colorfastness
One specimen, exposed and prepared as specified in 6.9 shall be wet out with a mild detergent and water solution and compared with a similarly treated unexposed specimen under natural (North sky) daylight or artificial daylight having a color temperature of 7600° Kelvin. The colorfastness shall be evaluated as follows:

Excellent - no perceptible change in color
 Good - perceptible but no appreciable change in color
 Fair - appreciable change in color.

Appreciable change in color means a change that is immediately noticeable in comparing the exposed specimen with the original comparison specimen. If closer inspection or a change of angle of light is required to make apparent a slight change in color, the change is not appreciable.

- 6.12 Resistance to Heat, Cold and Humidity

Three samples of retro-reflective sheeting, 3" x 6", applied to test panels in accordance with section 5.0, above shall be exposed as follows:

- 6.1.1 Heat. One specimen shall be placed in an oven at $71^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($160^{\circ}\text{F} \pm 5^{\circ}\text{F}$) for 24 hours, then conditioned as in section 5.0 for 2 hours.
- 6.12.2 Cold. The second specimen shall be exposed to an air temperature of $-57^{\circ}\text{C} \pm 3^{\circ}\text{C}$ ($-70^{\circ}\text{F} \pm 5^{\circ}\text{F}$) for 72 hours, then conditioned as in section 5.0 for 2 hours.
- 6.12.3 Humidity. The final specimen shall be subjected to 100% relative humidity at a temperature of $23^{\circ}\text{C} - 27^{\circ}\text{C}$ ($75^{\circ}\text{F} - 78^{\circ}\text{F}$) in accordance with Federal Test Method Standard 141, method 6201, for 24 hours, then conditioned as in section 5.0 for 24 hours.

Examination of each of the three samples following the exposures shall show no evidence of cracking, peeling, chipping or delaminating from the test panel. After heat exposure the sheeting shall retain a minimum of 85% and a maximum of 115% of the original coefficient of retro-reflection when measured at room temperature at all specified angles.

- 6.13 Fungus resistance: The retro-reflective sheeting shall comply with the supplementary requirements contained in section S1 of ASTM D 4956.
- 6.14 General Characteristics and Packaging: The retro-reflective sheeting as supplied shall be of good appearance, free from ragged edges, cracks and extraneous materials and shall be furnished in either rolls or sheets.

When furnished in continuous rolls, the number of splices shall not be more than two per 50 yards (45.7 m) of material, With a maximum of three pieces in any 50-yard (45.7 m) length. Splices shall be butted or overlapped and shall be suitable for continuous application as furnished.

The sheeting shall be packaged in accordance with commercially accepted standards. Each carton shall clearly stipulate the brand, quantity, size, lot or run number, color and type adhesive. Stored under normal conditions the retro-reflective sheeting as furnished shall be suitable for use for a minimum period of one year.

7.0 Performance Requirements and Obligations

7.1 Certification

The sheeting manufacturer shall submit with each lot or shipment, a certification that states the material supplied will meet all the requirements listed herein.

7.2 Field Performance Requirements

7.2.1 Type A, and B sheeting processed and applied to sign blank materials in accordance with sheeting manufacturer's recommendations, shall perform effectively for the number of years stated in Table III of this specification. The retro-reflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that: (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions; or (2) the coefficient of retro-reflection is less than the minimum specified for that sheeting during that period listed.

Level 1: 50% of values listed in Table II enclosed lens after 7 years

Level 2: 85% of values listed in Table II encapsulated lens after 7 years and
80% of values listed in Table II encapsulated lens after 10 years.

Level 3: 80% of values listed in Table II prismatic lens after 7 years and
70% of values listed in Table II prismatic lens after 10 years.

Failure of process inks or overlay films provided and/or sold for use on recommended sheeting shall constitute a failure of entire sign and shall be replaced under manufacturer's replacement obligations (7.3).

For screen printed transparent colored areas or transparent colored overlay films on white enclosed or encapsulated sheeting, the coefficients of retro-reflection shall not be less than 70% of the values for the corresponding color in the above table. For prismatic lens sheeting, the ratios of the R_A for the white to the R_A for the color, when measured at 0.2° observation, -4° entrance, and 0° rotation, shall be 5:1 to 15:1 for the red, and not less than 5:1 for blue and green.

All measurements shall be made after sign cleaning according to sheeting manufacturer's recommendations.

7.3 Sheeting Manufacturer's Replacement Obligation

Where it can be shown that retro-reflective signs with Types A, and B sheeting, supplied and used according to the sheeting manufacturer's recommendations, have not met the performance requirements of Section 7.2, the sheeting manufacturer shall cover restoration costs as follows for sheetings shown to be unsatisfactory during:

7.3.1 The entire 10 years encapsulated lens and prismatic lens, 7 years enclosed lens: the sheeting manufacturer will replace the sheeting required to restore the sign surface to its original effectiveness.

7.3.2 In addition, during the first 7 years for encapsulated lens and prismatic lens the sheeting manufacturer will cover the cost of restoring the sign surface to its original effectiveness at no cost to the using Agency for materials and labor.

7.4 Government Using Agency Obligation

The using Agency shall be responsible for requiring the dating of all signs at the time of application. That date constitutes the start of the field performance obligation period.

8.0 Technical Assistance Requirement

The manufacturer supplying the retro-reflective sheeting requirements shall provide at no charge the services of a qualified technician for instruction and training at the primary sign manufacturing facility designated by the Agency. This instruction shall be provided biannually and at the request of the Agency. Instruction shall include but not be limited to training films, material application, equipment operation, silk screening techniques, packaging, storage, and other proven sign shop practices as they apply to the reflective sheeting supplied by the manufacturer, and to assure that the resulting signs can comply with the applicable specifications.

Additional on-site technical assistance by the manufacturer supplying the retro-reflective sheeting shall be provided at each of the sign shops designated in the bid invitation. This assistance shall be provided annually and at the request of the Agency.

The sheeting manufacturer shall, without additional cost to the Agency, provide the sign shops with competent technical service and product information, including service on screen printing problems with the inks furnished or recommended by the manufacturer for their sheeting. The manufacturer supplying the retro-reflective sheeting shall provide technical assistance for their recommended sheeting application equipment. The manufacturer shall certify that trained personnel will be available on 72 hours notice to render such service to facilitate the manufacture of finished signs. "Service" is understood to mean the capability of calibration and troubleshooting, as well as the training and retraining of personnel as required. In addition, a manufacturer's representative shall be available on site within 24-hour notice to assess and advise on any manufacturing difficulty that arises.

9.0 Applicable Documents

The following documents, of the issues in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

9.1 ASTM Standards

- 9.1.1 B 209 Specification for Aluminum and Aluminum Alloy Sheet and Plate.
- 9.1.2 D 523 Standard Method for Test for Specular Gloss.
- 9.1.3 D 4956 Standard Specification for Retro-reflective Sheeting for Traffic Control.
- 9.1.4 E 284 Standard Definition of terms Relating to Appearance of Materials.
- 9.1.5 E 308 Standard Method for computing the colors of objects by using the CIE system.
- 9.1.6 E 810 Standard Test Method for Coefficient of Retro-reflection of Retro-reflective Sheeting.
- 9.1.7 E 1164 Standard Practice for obtaining spectrophotometric data for object color evaluation.

9.2 Other Standards

- 9.2.1 AASHTO M 268 Standard Specification for Retro-reflective Sheeting for Traffic Control
- 9.2.2 FHWA FP-96 Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects

**CITY OF TULSA
SPECIFICATIONS FOR
RETRO-REFLECTIVE SHEETING TYPE II-A**

I. DESCRIPTION

This specification covers a highly reflective grade of enclosed lens retro-reflective sheeting to be used on traffic control devices. The premium quality of Super Engineer Grade shall provide reflectivity and durability greater than the Engineer Grade enclosed lens sheeting and provide optimum visibility by day and night, under dry and wet conditions.

The sheeting shall consist of high quality glass spherical lens elements embedded within a flexible, transparent film having a smooth, flat outer surface.

II. REQUIREMENTS

A. SHEETING IDENTIFICATION

To distinguish this high grade of enclosed lens sheeting from others, a symbol shall be required in a repeat pattern, spaced approximately 4 to 8 inches apart. This symbol shall be printed underneath the top of the sheeting to ensure that it cannot fade or be wiped off of the sheeting surface with solvents. The symbol shall not interfere with the function of the retro-reflective device, but shall be visible to inspectors within three feet during day or night without the use of special devices.

B. COLOR REQUIREMENTS

The colors specified shall conform to the applicable requirements of AASHTO M 268, Table 1, except Orange and Red shall conform to Table 2.

Conformance of color requirements shall be determined by instrumental method in accordance with ASTM E 97. (Geometric characteristics must be confined to: Illumination incident with 10 degrees of and centered about a direction of 45 degrees from a perpendicular to the test surface. Condition of illumination and observation must not be interchangeable.) The test apparatus and test panels shall be in accordance with the manufacture's recommended procedures.

Calibration of the apparatus shall be the Munsell Papers (recently calibrated on a spectrophotometer) designed in Table 1. The test instrument used shall be one of the following or approved equal:

- Gardener Multipurpose Reflect-o-meter or Model XL20 Color Difference Meter.
- Gardener Model AC-2a Color Difference Meter or Model XL30 color Difference Meter.
- Meeco Model V Color-master.
- Hunter Lab D 25 Color Difference Meter.

C. SPECIFIC INTENSITY PER UNIT AREA (SIA)

The retro-reflective sheeting shall have the minimum SIA requirements specified as Type II-A in FP-85, Table 718-2 and shown in Table 2 herein. SIA is expressed in "candelas per foot-candle per square foot".

D. SIA DURING RAINFALL

The SIA of Super Engineer Grade, when totally wet, shall not be less than 90% of the day values in Table 2. Wet performance measurements shall be made in accordance with the standard rainfall test as specified in AASHTO M 268.

TABLE 1
COLOR SPECIFICATIONS LIMITS AND REFERENCE STANDARDS
SUPER ENGINEER GRADE

| Color | Chromaticity Coordinates* (Corner Points) | | | | | | | | Reflectance Limits (%Y) | | Reference*** Standard | |
|----------|--|------|------|------|------|------|------|------|----------------------------|------|--------------------------|-----------|
| | 1 | | 2 | | 3 | | 4 | | Y | | (Munsell Papers) | |
| | X | Y | X | Y | X | Y | X | Y | Min. | Max. | | |
| White ** | .305 | .290 | .350 | .342 | .321 | .361 | .276 | .308 | 35.0 | --- | 6.3GY | 6.77/0.8 |
| Red | .613 | .297 | .708 | .292 | .636 | .364 | .558 | .352 | 2.5 | 11 | 7.5R | 3/12 |
| Orange | .550 | .360 | .630 | .370 | .581 | .418 | .516 | .394 | 14.0 | 30 | 2.5YR | 5.5/14 |
| Brown | .445 | .353 | .604 | .396 | .556 | .443 | .445 | .386 | 4.0 | 9 | 5.0YR | 3/6 |
| Yellow | .482 | .450 | .532 | .465 | .505 | .494 | .475 | .485 | 29.0 | 45 | 1.25Y | 6/12 |
| Green | .130 | .369 | .180 | .391 | .155 | .460 | .107 | .439 | 3.5 | 9 | .65BG | 2.84/8.45 |
| Blue | .147 | .075 | .176 | .091 | .176 | .151 | .106 | .113 | 1.0 | 4 | 5.8PB | 1.32/6.8 |

* The four parts of chromaticity coordinates determine the acceptable color term of the CIE 1931 standard colorimetric system measured with the standard illumination Source C.

** Silver-white is an acceptable color designation.

*** Available from Munsell Color Company, 2441 Calvert Street, Baltimore, Maryland 21218.

TABLE 2
MINIMUM SPECIFIC INTENSITY PER UNIT AREA (SIA)
(CANDELAS PER FOORCANDLE PER SQUARE FOOT)
SUPER ENGINEER GRADE

| Observation Angle (*) | Entrance Angle (*) | White | Red | Orange | Brown | Yellow | Green | Blue |
|--------------------------|-----------------------|-------|-----|--------|-------|--------|-------|------|
| 0.2 | -4 | 140 | 30 | 60 | 5 | 100 | 30 | 10 |
| 0.2 | +30 | 60 | 12 | 22 | 2 | 36 | 10 | 4 |
| 0.5 | -4 | 50 | 10 | 20 | 2 | 33 | 9 | 3 |
| 0.5 | +30 | 28 | 6 | 12 | 1 | 20 | 6 | 2 |

E. SPECULAR GLOSS

The reflective sheeting shall have an 85% specular gloss of not less than 50 when tested in accordance with ASTM D 523.

F. COLOR PROCESSING

The sheeting shall permit cutting and color processing with compatible transparent and opaque process colors in accordance with the manufacturer's recommendation at temperatures of 60° F - 100° F (16°C - 38°C) and relative humidity of 20 - 80%. The sheeting shall be heat-resistant and permit force curing without staining of applied or unapplied sheeting at temperatures recommended by the sheeting manufacturer.

G. SHRINKAGE

A 9" x 9" (229mm x 229mm) reflective sheeting specimen with liner shall be conditioned a minimum of one hour at standard conditions. The liner shall be removed and the specimen placed on a flat surface with the adhesive side up. Ten minutes after the liner is removed and again after 24 hours, the specimen shall be measured to determine the amount of dimensional shrinkage. The reflective sheeting shall not shrink in any dimension more than 1/32 Inch (.08mm) in to minutes and not more than 1/8 Inch (3.2mm) in 24 hours.

H. FLEXIBILITY

The reflective sheeting shall be applied according to the manufacturer's recommendations to a clean etched 0.02" x 2" x 8" (.51mm x 50.8mm x 203.2mm) aluminum panel of alloy 6061-T6 and conditioned a minimum of 48 hours. When tested at 72°F (22.2°C) and 50° humidity, the sheeting shall be sufficiently flexible to show no cracking when bent around a 3/4 inch (19mm) mandrel.

I. ADHESIVE

The sheeting shall have either a pre-coated sensitive adhesive backing (Class I) or a heat activated backing (Class II) which shall provide for application of the sheeting without the necessity of additional coats on either the retro-reflective sheeting or application surface.

The Class I adhesive backing shall be a pressure sensitive adhesive of the aggressive tack type requiring no heat, solvent, or other preparation for adhesion to smooth, clean surfaces. The class II adhesive shall be activated by applying heat in excess of 175°F (79°C) to the material as in a heat-vacuum process of sign fabrication.

Both adhesive classes shall be protected by a liner which shall be easily removable by peeling without soaking in water or other solvents without breaking, tearing or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for 4 hours at 160°F (71.1°C) under a weight of 2.5 pounds (1.125kg) per square inch.

The adhesive backing of the reflective sheeting shall produce a bond to support a 1.75 pound (.79kg) weight for 5 minutes, without the bond peeling for a distance of more than 2 inches (50.8mm) when applied to a test panel tested in accordance with AASHTO M 268.

J. IMPACT RESISTANCE

The reflective sheeting material, applied according to the manufacturer's recommendations to a clean, etched aluminum panel of alloy 6061 - T6, 0.04" x 3" x 5" (.10mm by 76mm x 127mm) and conditioned for 24 hours at 73°F (23°C) and 50% relative humidity, shall show no cracking or delamination when the face of the panel is subjected to an impact of a 2 pound (0.9kg) weight with a 5/8 inch (16mm) rounded tip dropped for a 10 inch-pound (11.5cm-kg) setting of a Gardener Variable Impact Tester, IG-1120.

III. DURABILITY

The durability of the Super Engineer Grade reflective sheeting shall be substantiated by compliance with one or both of the following accelerated weathering tests:

A. OUTDOOR TEST

Processed and applied in accordance with testing procedures in ASTM G 7, the Super Engineer Grade sheeting shall be weather resistant, resistant to dirt and fungus accumulated and following cleaning, shall show no appreciable discoloration, cracking, crazing, blistering or dimensional change and not less than 70% of the minimum brightness values of Table 2 when exposed to accelerated weathering for 2 years, south facing, unprotected at 45° in South Florida. The Orange sheeting shall meet 75% of table 2 after 1 year.

B. WEATHEROMETER TEST

Processed and applied in accordance with recommended procedures, the Super Engineer Grade Sheeting shall be weather resistant and, following cleaning in accordance with manufacturer's recommendation shall show no appreciable discoloration, cracking, blistering or dimensional change. Following exposure, the panel shall be washed with a 5 percent hydrochloric acid solution for 45 seconds, rinsed thoroughly with clean water, blotted with a soft cloth, brought to equilibrium and standard conditions and tested. It shall not have less than 65% of the specific minimum SIA values of Table 2 when exposed to 2,200 hours of weathering in accordance with ASTM G 23. Type E or EH with humidifier off. The Orange sheeting shall meet 75% of Table 2 after 500 hours.

IV. CONFORMANCE

The sheeting manufacturer shall substantiate conformance to the requirements of this specification by providing to the user agency one of the following:

1. A certified test report from a qualified domestic U.S. Independent testing laboratory showing that representative production material of the type to be supplied has met the requirements of this specification.
2. Provide documented evidence to the satisfaction of the user agency that representative production material of the Type to be supplied has been used successfully in a substantial traffic signing program in similar climatic conditions for at least 3 years.

FLUORESCENT YELLOW-GREEN SPECIFICATION

- 1.0 Scope. This specification covers flexible, colored, fluorescent wide angle prismatic retro-reflective sheeting, tape and related processing materials designed to enhance the visibility of traffic control signs and objects under all driving conditions, day and night.
- 2.0 Classification. The sheeting shall be a visible-activated fluorescent retro-reflector providing higher daytime brightness than ordinary colored sheetings of similar chromaticity. The sheeting shall be of the following retro-reflective types as specified in the plans or in the invitation to bid.
- 2.1 Type A:
Type A sheeting is wide angle retro-reflective sheeting with optimized performance over a broad range of observation angles. It is intended to provide high sign brightness especially at short sight distance where other sheetings do not.
- 3.0 Applicable Documents. The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:
- 3.1 ASTM Standards.
- | | | |
|-------|--------|--|
| 3.1.1 | B-117 | Method of salt spray (fog) testing. |
| 3.1.2 | B-209 | Specification for Aluminum and Aluminum Alloy Sheet and Plate. |
| 3.1.3 | D- 523 | Standard Method for Test for Specular Gloss. |
| 3.1.4 | E-284 | Standard Definition of Terms Relating to Appearance of Materials. |
| 3.1.5 | E-308 | Computing the Colors of Objects by Using the CIE System. |
| 3.1.6 | E-810 | Standard Test Method for Coefficient of Retro-reflection of Retro-reflective Sheeting. |
| 3.1.7 | E-1164 | Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation. |
| 3.1.8 | E-991 | Standard Practice for color Measurement of Fluorescent Specimens. |
- 4.0 Description. The retro-reflective sheeting shall have a smooth surface with a distinctive interlocking diamond seal pattern and datum orientation marks visible from the face. The sheeting shall be pre-coated with a pressure sensitive adhesive backing protected by a removable liner.
- 5.0 Test Methods.
- 5.1 Test Conditions. Unless otherwise specified herein, all applied and unapplied test samples and specimens shall be conditioned at the standard conditions of $23 \pm 3^{\circ}\text{C}$ ($73^{\circ} \pm 3^{\circ}\text{F}$) and $50 \pm 5\%$ relative humidity for 24 hours prior to testing.
- 5.2 Test Panels. Unless otherwise specified herein, when tests are to be performed using test panels, the specimens of retro-reflective material shall be applied to smooth aluminum cut from ASTM B-209 Alloy 5052-H36, 5052-H38, 5154-H38 or 6061-T6 sheets in 0.05 cm (0.020 in.), 0.10 cm (0.040 in.) or 0.16 cm (0.063 in.) thickness. The aluminum shall be degreased and lightly acid etched before the specimens are applied. The specimens shall be applied to the panels in accordance with the recommendations of the retro-reflective sheeting manufacturer.
- 6.0 Physical Requirements.
- 6.1 Color Requirements.
- 6.1.1 Color Test. Conformance to daytime color requirements of Table I shall be determined instrumentally on sheeting applied to aluminum test panels, using a 2-monochromator spectro-photo-meter employing annular 45/0 (or equivalent 0/45) illuminating and viewing geometry.^{1,2} The total chromaticity coordinates and total luminance factor shall be calculated from the total spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E-308 "Practice for Computing the Colors of Objects by Using the CIE System" for the CIE 1931 (2°) standard colorimetric observer. The measurements shall be made on a Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

TABLE I

Color Specification Limits For New Sheeting* (Daytime)

| Color | Sheeting Type | Chromaticity Coordinate 1 | | Chromaticity Coordinate 2 | | Chromaticity Coordinate 3 | | Chromaticity Coordinate 4 | | Total Luminance Factor Limit, Y_T | |
|--------------------------|---------------|---------------------------|-------|---------------------------|-------|---------------------------|-------|---------------------------|-------|-------------------------------------|------|
| | | x | y | x | y | x | y | x | y | min. | max. |
| Fluorescent Yellow Green | A | 0.387 | 0.610 | 0.460 | 0.540 | 0.421 | 0.486 | 0.368 | 0.539 | 60% | ---- |
| | B | 0.387 | 0.610 | 0.460 | 0.540 | 0.421 | 0.486 | 0.368 | 0.539 | 55% | ---- |

* The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D65.

6.2 Fluorescence Requirements

6.2.1 Fluorescence Test. Conformance to fluorescence luminance factor requirements in Tables II and IV, shall be determined instrumentally, on sheeting applied to aluminum test panels, using a 2-monochromator spectrophotometer employing annular 45/0 (or equivalent 0/45) illuminating and viewing geometry.^{1 2} The fluorescence luminance factor shall be calculated from the fluorescence spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E-308 "Practice for Computing the Colors of Objects by Using the CIE System" for the CIE 1931 (2°) standard colorimetric observer. The measurements shall be made on a Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

Table II

| Minimum Fluorescence Luminance Factor - New Sheeting | |
|--|--|
| Sheeting Type | Fluorescent Luminance Factor Limit, Y _F |
| | Min. |
| A | 35% |

6.3 Coefficient of Retro-reflection, R_A. The coefficients of retro-reflection shall not be less than the minimum values specified in Tables IIIA according to the sheeting type. Testing shall be in accordance with ASTM E-810 except that the angle of rotation shall be specified.

6.3.1 Units. Coefficients of retro-reflection R_A shall be specified in units of candelas per lux per square meter.

6.3.2 The datum mark (arrow) imprinted on the face of the sheeting shall be the datum mark for test purposes. The testing shall be performed at 0° rotation and 90° rotation according to the tables below. For the 0° rotation angle, the direction of the datum mark shall be parallel to the entrance plane. For the 90° rotation angle the datum mark is perpendicular to the entrance plane.

TABLE IIIA
For Type A Sheeting
Minimum Coefficient of Retro-reflection R_A
(Candelas per lux per square meter)

| Observation Angle | Rotation Angle | Entrance Angle | | |
|-------------------|----------------|----------------|-----|-----|
| | | -4° | 30° | 45° |
| 0.1° | 0 ° | 560 | 465 | 30 |
| 0.1° | 90° | 525 | 300 | 160 |
| 0.2° | 0 ° | 375 | 225 | 25 |
| 0.2° | 90° | 275 | 180 | 125 |
| 0.5° | 0 ° | 225 | 145 | 7 |
| 0.5° | 90° | 250 | 70 | 40 |
| 1.0° | 0 ° | 75 | 45 | 4 |
| 1.0° | 90° | 50 | 25 | 12 |

¹ "Design and testing of a two-monochromator reference spectrofluorimeter for high-accuracy total radiance factor measurements" by Joanne C. Zwinkels, D.S. Gignac, M. Nevins, I. Powell, and A. Bewsher, Applied Optics, Vol. 36 no. 4, pp. 892-902 (1997).

² "Principles of Bispectral Fluorescence Colorimetry" by Jim Leland, N. Johnson, and A. Arecchi, Proceedings of SPIE - The International Society for Optical Engineering: Vol. 3140, pp. 76-87 (1997).

- 6.4 Gloss. The retro-reflective sheeting shall have an 85° specular gloss of not less than 50 when tested in accordance with ASTM D-523.
- 6.5 Color Processing. The retro-reflective sheeting shall permit cutting and color processing with compatible transparent and opaque process colors in accordance with the sheeting manufacturer's recommendations at temperatures of 15° to 38°C (59 to 100°F) and relative humidities of 20% to 80%. The sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures recommended by the sheeting manufacturer.
- 6.6 Flexibility. The retro-reflective sheeting with the liner removed and conditioned as in 5.1 shall be sufficiently flexible to show no cracking when slowly bent, in one seconds' time, around a 3 mm (1/8 in.) mandrel, with the adhesive contacting the mandrel, at test conditions. Talcum powder shall be spread on the adhesive to prevent sticking to the mandrel.
- 6.7 Adhesive. The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solutions, without breaking, tearing, or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for 4 hours at 70°C (158°F) under a weight of .175 Kg/cm² (2.5 pounds per square inch). The adhesive backing of the retro-reflective sheeting shall produce a bond to support a .80 Kg (1.75 pound) weight for 5 minutes without the bond peeling for a distance of more than 5.0 cm (2.0 inches) when applied to a test panel as described in 5.2. Apply 10 cm (4 inches) of a 2.5 cm x 15 cm (1" x 6") specimen to a test panel. Condition and then position the panel face down horizontally, suspend the weight from the free end of the sample and allow it to hang free at an angle of 90° to the panel surface for 5 minutes.
- 6.8 Impact Resistance. The retro-reflective sheeting applied according to the sheeting manufacturer's recommendations to a test panel of alloy 6061 -T6, 0.10 cm (0.040 in) by 7.5 cm (3 in) by 12.5 cm (5 in) and conditioned as in 5.1, shall show no cracking outside the impact area when the face of the panel is subjected to an impact of 11.3 Nm (100 inch-pounds) using a weight with a 1.6 cm (5/8 in.) diameter rounded tip dropped from a height necessary to generate an impact of 11.3 Nm, at test temperatures of both 0°C (32°F) and 22°C (72°C).
- 6.9 Resistance to Accelerated Outdoor Weathering. The retro-reflective surface of the sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing, or dimensional change after 3 years unprotected outdoor exposure, facing the equator and inclined 45° from the vertical. Following weather exposure, panels shall be washed in a 5% HCL solution for 45 seconds, rinsed thoroughly with clean water, blotted with a soft clean cloth and brought to equilibrium at standard conditions. After cleaning, the coefficient of retro-reflection and the fluorescence luminance factor shall not be less than the values in Table IVA or IVB when measured at 0° rotation and 90° rotation. The color shall conform to the chromaticity coordinates of Table I. The sample shall:
- 6.1.1 Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 0.8 mm (1/32 inch) shrinkage or expansion.
- 6.1.2 Where more than one panel of a color is measured, the coefficient of retro-reflection shall be the average of all determinations.

TABLE IVA
For Type A Sheeting
Minimum Coefficient of Retro-reflection R_A (cd/lux/m²)
and Fluorescent Luminance Factor Y_F after Accelerated Outdoor Weathering

| Color | Warranty Period | Minimum Coefficient of Retro-reflection, (R_A) cd/lux/m ² | | | Minimum Fluorescence Luminance Factor, Y_F |
|--------------|-----------------|---|----------------|--------------------|--|
| | | Observation Angle | Rotation Angle | -4° Entrance Angle | |
| Yellow-Green | 7 Years | 0.2° | 0° | 190 | 20 % |
| | | 0.2° | 90° | 140 | |
| | | 1.0° | 0° | 40 | |
| | | 1.0° | 90° | 25 | |

- 6.10 Optical Stability. Three pieces of retro-reflective sheeting applied to test panels and conditioned as in Section 5.1 shall each first have their photo-metric properties characterized by measuring the coefficients of retro-reflection according to the provisions in Section 6.2 at all test geo-metries shown in Table IIIA for Type A Sheeting. These panels shall then be exposed in an air circulating oven at 170 ± 5°F (77 ± 3°C) for a period of 24 hours. After exposure the panels shall be allowed to condition according to the provisions of Section 5.1. These panels will again be characterized for photo-metric properties by measuring the coefficients of retro-reflection according to the provisions of Section 6.2 at all test geometries measured before exposure.

The coefficients of retro-reflection measured after exposure shall be between 85% and 115% of the values measured before exposure for each of the three samples.

- 6.11 Resistance to Corrosion. The retro-reflective sheeting applied to a test panel and conditioned as in 5.1, shall show no loss of adhesion, appreciable discoloration or corrosion and after cleaning shall retain a minimum of 80% of the original coefficient of retro-reflection when measured at 0.2° observation, -4° entrance and 0° rotation angles after 1000 hours exposure to a 5% concentration salt spray at 35°C (95°F) when tested in accordance with ASTM B 117.
- 6.12 General Characteristics and Packaging. The retro-reflective sheeting as supplied shall be of good appearance, free from ragged edges, cracks and extraneous materials, and shall be furnished in either rolls or sheets. When furnished in continuous rolls, the average number of splices shall not be more than 3 per 50 yards (45.7 meters) of material with a maximum of 4 pieces in any 50 yard (45.7 meters) length. Splices shall be butted or overlapped and shall be suitable for continuous application as furnished. When furnished as cut sheets or sign faces, the sheeting shall be packaged flat in accordance with commercially accepted standards. The sheeting shall be packed snugly in corrugated fiberboard cartons, in accordance with commercially accepted standards. Each carton shall clearly stipulate the brand, quantity, size, lot or run number and color. Stored under normal conditions the retro-reflective sheeting as furnished shall be suitable for use for a minimum period of one year.

7.0 Sheeting Manufacturer's Warranty

- 7.1 Certification. The sheeting manufacturer shall, upon request, submit with each lot or shipment, a certification which states that the material supplied will meet all of the requirements listed herein.
- 7.2 Field Performance Requirements.
 - 7.2.1 Fluorescent retro-reflective sheeting which is used for vertically mounted traffic control and guidance signs which are processed and applied to aluminum sign blank materials in accordance with the sheeting manufacturer's recommendations, shall perform effectively for a minimum 7 years from the date of fabrication. The retro-reflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that: (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by a driver with normal vision; or (2) the coefficient of retro-reflection, after cleaning, is less than the minimums specified in Table IVA (for Type A Sheeting) or (3) the fluorescence luminance factor after cleaning, is less than the minimums specified in Tables IVA .
 - 7.2.2 All measurements shall be made after sign cleaning according to the sheeting manufacturer's recommendations.
 - 7.2.3 Natural causes include effects of exposure to weather. Natural causes exclude (without limitation) damage from exposure to chemicals, abrasion and other mechanical damage from fasteners used to mount the sign, collisions or mishandling.
- 7.3 Sheeting Manufacturer's Replacement Obligation
 - 7.3.1 Where it can be shown that the retro-reflective sheeting fails to conform to the performance requirements of Section 7.2, the sheeting manufacturer's sole responsibility and purchaser's and user's exclusive remedy shall be:
 - 7.3.1.1 If the failure occurs within the first 60 months from the date of fabrication, the sheeting manufacturer shall, at its expense, restore the sign surface to its original effectiveness.
 - 7.3.1.2 If the failure occurs from the 61st to the 84th month from the date of fabrication, the sheeting manufacturer shall furnish the necessary amount of sheeting to restore the sign surface to its original effectiveness.
 - 7.3.1.3 Replacement sheeting shall carry the unexpired warranty of the sheeting it replaces.
- 7.4 Process Inks. The manufacturer of the sheeting shall furnish at no additional cost the process inks, clears and thinners recommended for the sheeting to meet the performance requirements of this specification, and shall further be responsible for technical assistance in the use of these inks in accordance with section 8.

- 7.5 Slip Sheet. Slip sheet paper, if recommended by the sheeting manufacturer for sheeting surface protection or for use in packing, storage or shipping finished signs, shall be furnished in rolls by the manufacturer at no additional charge, in at least equal dimension (square meters) and in the same widths as the sheeting supplied.
- 7.6 Washers. Washers, if recommended by the sheeting manufacturer to protect the sign surface from damage by bolts or other fasteners, shall be furnished by the manufacturer at no additional charge.

8.0 Technical Assistance Requirements.

8.1 Instruction and Training.

- 8.1.1 The manufacturer supplying the sheeting requirements shall provide the services of a qualified technician for instruction and training at the primary sign manufacturing facility designated by the agency. This instruction shall be available on a quarterly basis at no additional cost, and shall include but not be limited to, training films, material application, equipment operation, silk screening techniques, packaging, storage and other proven sign shop practices as they apply to the reflective sheeting supplied by the manufacturer, and to assure that the resulting signs can comply with the applicable specifications.
- 8.1.2 Additional on-site technical assistance by the manufacturer supplying the retro-reflective sheeting shall be provided at each of the sign shops designated in the bid invitation. This assistance will be provided at least once during each quarter of sign production, if required.

8.2 Equipment. The manufacturer supplying the retro-reflective sheeting requirements shall provide service for sheeting application equipment of their manufacture, certify that trained personnel will be available on 72 hours notice to render such service, and shall stock authorized parts for their sheeting application equipment. "Service" is understood to mean the capability of calibration and trouble shooting, as well as the training and retraining of personnel as required.

8.3 Compliance. Failure to comply with the requirements and schedules of 8.1 and 8.2 shall be cause for cancellation of contract.

9.0 Government Using Agency Obligation. The using agency shall be responsible for requiring the dating of all signs at the time of fabrication with the fabrication date so that the start of the warranty period can be determined. In the event of claims made under the warranty the agency shall notify the sheeting manufacturer of the failure within a reasonable time of the failure, provide reasonable information requested by the sheeting manufacturer and permit the manufacturer to verify the cause of the failure.

Patented Devices, Materials and Processes. Seller will pay any damages, costs or fines resulting from any claims against the agency for infringement or alleged infringement of third party patents by product supplied by Seller under this specification. The costs paid by Seller shall include legal and court costs deemed reasonably necessary by counsel for the agency in defending against such claims.

FLUORESCENT ORANGE SPECIFICATION FOR THE WORK ZONE

I. Description

The fluorescent orange wide angle prismatic retro-reflective sheeting is specifically designed for use on rigid substrate work zone signs to provide high visual impact under nighttime and daytime driving conditions, including low visibility periods such as dawn, dusk, and overcast days. The sheeting shall consist of prismatic lenses formed in a transparent fluorescent orange synthetic resin, sealed, and backed with an aggressive pressure sensitive adhesive protected by a removable liner. The sheeting shall have a smooth surface with a distinctive interlocking diamond seal pattern and orientation marks visible from the face.

II. Requirements

A. Photo-metric - Coefficient of Retro-reflection RA

When the sheeting applied on aluminum test panels is measured in accordance with ASTM E 810, it shall have minimum coefficient of retro-reflection values as shown in Table I. The rotation angle shall be $\pm 90^\circ$, the observation angles shall be 0.2° and 0.5° , the entrance angles (component β_1) shall be -4° , $+30^\circ$, and $+50^\circ$, and the entrance angle component $\beta_2 = 0^\circ$.

TABLE I
Minimum Coefficient of Retro-reflection RA
(Candelas per foot-candle per square foot)
(90° Rotation Angle*)

| Observation Angle (°) | Entrance Angle (°) | Orange |
|-------------------------|----------------------|--------|
| 0.2 | -4 | 200 |
| 0.2 | +30 | 120 |
| 0.2 | +50 | 50 |
| 0.5 | -4 | 80 |
| 0.5 | +30 | 50 |
| 0.5 | +50 | 20 |

* The datum mark (arrow) imprinted on the face of the sheeting shall be the datum mark for test purposes. For the specified 90° rotation angle, the sheeting shall be positioned on the goniometer so that the direction of this datum mark is perpendicular to the observation plane (this geometry is equivalent to a 90° orientation angle with a presentation angle of 0° in the measurement geometry described in Fed. Test Method Standard 370).

B. Daytime Color

Color shall conform to the requirements of Tables II. Daytime color and maximum spectral radiance factor (peak reflectance) of sheeting mounted on aluminum test panels shall be determined instrumentally in accordance with ASTM E 991. The values shall be determined on a HunterLab Labscan 6000 0/45 Spectrocolorimeter with option CMR 559 [or approved equal 0/45 (45/0) instrument with circumferential viewing (illumination)]. Computations shall be done in accordance with ASTM E 308 for the 2° observer.

TABLE II
Color Specification Limits** (Daytime)

| Color | 1 | | 2 | | 3 | | 4 | | Reflectance Limit Y (%) | |
|--------------------|------|------|------|------|------|------|------|------|-------------------------|------|
| | X | Y | X | Y | X | Y | X | Y | Min. | Max. |
| Orange (New) | .583 | .416 | .523 | .397 | .560 | .360 | .631 | .369 | 30 | - |
| Orange (Weathered) | .583 | .416 | .523 | .397 | .560 | .360 | .631 | .369 | 20 | 45 |

Maximum spectral radiance factor, new: 110%, min.
Weathered: 60%, min.

** The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D65.

C. Nighttime Color.

Nighttime color of the sheeting applied to aluminum test panels shall be determined instrumentally in accordance with ASTM E 811 and calculated in the u' , v' coordinate system in accordance with ASTM E 308. Sheeting shall be measured at 0.33° observation and -4° entrance at 90° rotation. Color shall conform to the requirements of Table III.

TABLE III
Color Specification Limits** (Nighttime)

| Color | 1 | | 2 | | 3 | | 4 | |
|-------------------------------|------|------|------|------|------|------|------|------|
| | u' | v' | u' | v' | u' | v' | u' | v' |
| Orange (new and weathered) | .400 | .540 | .475 | .529 | .448 | .522 | .372 | .534 |

D. Resistance to Accelerated Weathering.

The retro-reflective surface of the sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing, or dimensional change after 1 year's unprotected outdoor exposure in south Florida, south-facing and inclined 45° from the vertical, or after 1500 hours' exposure in a xenon arc weather-o-meter in accordance with ASTM G 26, Type B, Method A. Following exposure, panels shall be washed in a 5% HCL solution for 45 seconds, rinsed thoroughly with clean water, blotted with a soft clean cloth and brought to equilibrium at standard conditions. After cleaning, the coefficient of retro-reflection shall be not less than 100 when measured as in D.2, below, and the color is expected conform to the requirements of Tables II and III for weathered sheeting. The sample shall:

1. Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 1/32 inch (0.08 cm) shrinkage or expansion.
2. Be measured only at angles of 0.2° observation, -4° entrance and 90° rotation. Where more than one panel of a color is measured, the coefficient of retro-reflection shall be the average of all determinations.

E. Impact Resistance.

The retro-reflective sheeting applied according to the sheeting manufacturer's recommendations to a test panel of alloy 6061-T6, 0.040" (0.10 cm) by 3" (7.6 cm) by 5" (12.7 cm) and conditioned for 24 hours, shall show no cracking outside the impact area when the face of the panel is subjected to an impact of 100 inch-pounds (11.3 Nm) using a weight with a 5/8 in. (15.8 mm) diameter rounded tip dropped from a height necessary to generate an impact of 100 inch-pounds, at test temperatures of both 32° F (0° C) and 72° F (22° C) .

F. Resistance to Heat.

The retro-reflective sheeting, applied to a test panel as in E., above, and conditioned for 24 hours, shall be measured in accordance with paragraph. A. at 0.2° observation and -4° entrance angles at 90° rotation and exposed to 170 + 5° F (77 + 3° C) for 24 hours in an air circulating oven. After heat exposure the sheeting shall retain a minimum of 70% of the original coefficient of retro-reflection.

G. Field Performance.

Retro-reflective sheeting processed and applied to sign blank materials in accordance with the sheeting manufacturer's recommendations, is expected to perform effectively for a minimum of 3 years. The retro-reflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that: (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions; or (2) the coefficient of retro-reflection is less than 100 when measured at 0.2° observation and -4° entrance at 90° rotation. All measurements shall be made after sign cleaning according to the sheeting manufacturer's recommendations.

FLUORESCENT YELLOW SHEETING SPECIFICATION

1.0 Scope. This specification covers flexible, colored, fluorescent wide angle prismatic retro-reflective sheeting, tape and related processing materials designed to enhance the visibility of traffic control signs and objects under all driving conditions, day and night.

2.0 Classification. The sheeting shall be a visible-activated fluorescent retro-reflector providing higher daytime brightness than ordinary colored sheetings of similar chromaticity. The sheeting shall be of the following retro-reflective type as specified in the plans or in the invitation to bid.

The sheeting shall be a wide-angle retro-reflective sheeting with optimized performance over a broad range of observation and entrance angles. It is intended to provide high sign brightness at all viewing distances but especially at short sight distance where other sheetings do not.

3.0 Applicable Documents. The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

3.1 ASTM Standards.

| | | |
|--------|--------|--|
| 3.1.1 | B-117 | Method of salt spray (fog) testing. |
| 3.1.2 | B-209 | Specification for Aluminum and Aluminum Alloy Sheet and Plate. |
| 3.1.3 | D-523 | Standard Method for Test for Specular Gloss. |
| 3.1.4 | E-284 | Standard Definition of Terms Relating to Appearance of Materials. |
| 3.1.5 | E-308 | Computing the Colors of Objects by Using the CIE System. |
| 3.1.6 | E-810 | Standard Test Method for Coefficient of Retro-reflection of Retro-reflective Sheeting. |
| 3.1.7 | E-811 | Standard Practice for Measuring Colorimetric Characteristics of Retro-reflectors under Nighttime Conditions. |
| 3.1.8 | E-991 | Standard Practice for color Measurement of Fluorescent Specimens. |
| 3.1.9 | E-1164 | Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation. |
| 3.1.10 | E-1247 | Standard Test Method for Identifying Fluorescence in Object - Color Specimens by Spectroscopy. |

4.0 Description. The retro-reflective sheeting shall have a smooth surface with a distinctive interlocking diamond seal pattern and datum orientation marks visible from the face. The sheeting shall be pre-coated with a pressure sensitive adhesive backing protected by a removable liner.

5.0 Test Methods.

5.1 Test Conditions. Unless otherwise specified herein, all applied and unapplied test samples and specimens shall be conditioned at the standard conditions of $23 \pm 3^{\circ}\text{C}$ ($73^{\circ} \pm 3^{\circ}\text{F}$) and $50 \pm 5\%$ relative humidity for 24 hours prior to testing.

5.2 Test Panels. Unless otherwise specified herein, when tests are to be performed using test panels, the specimens of retro-reflective material shall be applied to smooth aluminum cut from ASTM B-209 Alloy 5052-H36, 5052-H38, 5154-H38 or 6061-T6 sheets in 0.05 cm (0.020 in.), 0.10 cm (0.040 in.) or 0.16 cm (0.063 in.) thickness. The aluminum shall be degreased and lightly acid etched before the specimens are applied. The specimens shall be applied to the panels in accordance with the recommendations of the retro-reflective sheeting manufacturer.

6.0 Physical Requirements.

6.1 Daytime Color Requirements.

6.2.1 Daytime Color Test. Conformance to daytime color requirements of Table A shall be determined instrumentally on sheeting applied to aluminum test panels, using a 2-monochromator spectrophotometer employing annular 45/0 (or equivalent 0/45) illuminating and viewing geometry.³ The total chromaticity coordinates and total luminance factor shall be calculated from the total spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E-

308 "Practice for Computing the Colors of Objects by Using the CIE System" for the CIE 1931 (2°) standard colorimetric observer. The measurements shall be made on a Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

| Table A | | | | | | | | | |
|---|---------------------------|-------|---------------------------|-------|---------------------------|-------|---------------------------|-------|-----------------------------------|
| CIE Daytime Chromaticity Coordinate Limit* and Total Luminance Factor Minimum for New Sheeting* | | | | | | | | | |
| Color | Chromaticity Coordinate 1 | | Chromaticity Coordinate 2 | | Chromaticity Coordinate 3 | | Chromaticity Coordinate 4 | | Total Luminance Factor Y (%) min. |
| | X | y | x | y | x | y | x | Y | |
| Fluorescent Yellow | 0.521 | 0.424 | 0.557 | 0.442 | 0.479 | 0.520 | 0.454 | 0.491 | 40% |

* The four pairs of chromaticity coordinates determine the acceptable color in terms of The CIE 1931 Standard Colorimetric System measured with standard illuminant D₆₅.

6.2 Fluorescence Requirements

6.2.1 Fluorescence Test. Conformance to fluorescence luminance factor requirements in Tables B and E, shall be determined instrumentally, on sheeting applied to aluminum test panels, using a 2-monochromator spectrophotometer employing annular 45/0 (or equivalent 0/45) illuminating and viewing geometry.⁴ The fluorescence luminance factor

³ "Metrology of fluorescent retro-reflective materials and its relationship to their daytime visibility" by David M. Burns and Norbert

L. Johnson, Analytica Chimica Acta, 380, 211-226 (1999).

⁴ "Metrology of fluorescent retro-reflective materials and its relationship to their daytime visibility" by David M. Burns and Norbert

L. Johnson, Analytica Chimica Acta, 380, 211-226 (1999).

shall be calculated from the fluorescence spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E-308 "Practice for Computing the Colors of Objects by Using the CIE System" for the CIE 1931 (2°) standard colorimetric observer. The measurements shall be made on a Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

| Table B | |
|--|-------------------------|
| Fluorescence Luminance Factor Minimum for New Sheeting | |
| Color | Y _F (%) min. |
| Fluorescent Yellow | 25 |

- 6.3 Coefficient of Retro-reflection, R_A. The coefficients of retro-reflection shall not be less than the minimum values specified in Tables C and E. Testing shall be in accordance with ASTM E-810 and the values of 0° rotation and 90° rotation will be averaged to determine the R_A.
- 6.3.1 Units. Coefficients of retro-reflection R_A shall be specified in units of candelas per lux per square meter.
- 6.3.2 The datum mark (arrow) imprinted on the face of the sheeting shall be the datum mark for test purposes. For the 0° rotation angle, the direction of the datum mark shall be parallel to the entrance plane. For the 90° rotation angle the datum mark is perpendicular to the entrance plane.

| Table C | | | |
|---|----------------|-----|-----|
| Minimum Coefficient of Retro-reflection | | | |
| R _A for New Sheeting (cd/lux/m ²) | | | |
| Observation Angle | Entrance Angle | | |
| | -4° | 30° | 45° |
| 0.1° | 400 | 250 | 70 |
| 0.2° | 240 | 150 | 55 |
| 0.5° | 165 | 75 | 15 |
| 1.0° | 45 | 24 | 6 |

- 6.4. Nighttime Color (x, y). The chromaticity coordinates of the reflective sheeting conform to Table D below.

- 6.2.1 Nighttime Color Test. Conformance to nighttime color requirements of Table D shall be determined instrumentally on sheeting applied to aluminum test panels. Testing shall be in accordance with ASTM E-811. The total chromaticity coordinates shall be calculated from the total spectral radiance factors computed for CIE illuminant A in accordance with ASTM E-308 "Practice for Computing the Colors of Objects by

Using the CIE System" for the CIE 1931 (2°) standard colorimetric observer.

| Table D | | | | | | | | |
|---|---------------------------|-------|---------------------------|-------|---------------------------|-------|---------------------------|-------|
| CIE Nighttime Chromaticity Coordinate Limits* for New Sheeting* | | | | | | | | |
| Color | Chromaticity Coordinate 1 | | Chromaticity Coordinate 2 | | Chromaticity Coordinate 3 | | Chromaticity Coordinate 4 | |
| | x | Y | x | y | x | y | x | y |
| Fluorescent Yellow | 0.554 | 0.445 | 0.610 | 0.390 | 0.569 | 0.394 | 0.527 | 0.436 |

* The four pairs of chromaticity coordinates determine the acceptable color limits for CIE A illumination in terms of the CIE 1931 Standard Colorimetric System.

- 6.5 Gloss. The retro-reflective sheeting shall have an 85° specular gloss of not less than 50 when tested in accordance with ASTM D-523.
- 6.6 Color Processing. The retro-reflective sheeting shall permit cutting and color processing with compatible transparent and opaque process colors in accordance with the sheeting manufacturer's recommendations at temperatures of 15° to 38°C (59 to 100°F) and relative humidities of 20% to 80%. The sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures recommended by the sheeting manufacturer.
- 6.7 Flexibility. The retro-reflective sheeting with the liner removed and conditioned as in 5.1 shall be sufficiently flexible to show no cracking when slowly bent, in one seconds' time, around a 3 mm (1/8 in.) mandrel, with the adhesive contacting the mandrel, at test conditions. Talcum powder shall be spread on the adhesive to prevent sticking to the mandrel.
- 6.8 Adhesive. The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solutions, without breaking, tearing, or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for 4 hours at 70°C (158°F) under a weight of 0.175 Kg/cm² (2.5 pounds per square inch). The adhesive backing of the retro-reflective sheeting shall produce a bond to support a 0.80 Kg (1.75 pound) weight for 5 minutes without the bond peeling for a distance of more than 5.0 cm (2.0 inches) when applied to a test panel as described in 5.2. Apply 10 cm (4 inches) of a 2.5 cm x 15 cm (1" x 6") specimen to a test panel. Condition and then position the panel face down horizontally, suspend the weight from the free end of the sample and allow it to hang free at an angle of 90° to the panel surface for 5 minutes.
- 6.9 Impact Resistance. The retro-reflective sheeting applied according to the sheeting manufacturer's recommendations to a test panel of alloy 6061 -T6, 0.10 cm (0.040 in) by 7.6 cm (3 in) by 15.2 cm (6 in) and conditioned as in 5.1, shall show no cracking outside the impact area when the face of the panel is subjected to an impact of 5.7 Nm (50 inch-pounds) using a weight with a 1.6 cm (5/8 in.) diameter rounded tip dropped from a height necessary to generate an impact of 5.7 Nm, at test temperatures of both 0°C (32°F) and 22°C (72°C).

6.10 Resistance to Accelerated Outdoor Weathering. The retro-reflective surface of the sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing, or dimensional change after 3 years unprotected outdoor exposure, facing the equator and inclined 45° from the vertical. Following weather exposure, panels shall be washed in a 5% HCL solution for 45 seconds, rinsed thoroughly with clean water, blotted with a soft clean cloth and brought to equilibrium at standard conditions. After cleaning, the coefficient of retro-reflection and the fluorescence luminance factor shall not be less than the values in Table E. The color shall conform to the chromaticity coordinates of Tables A and D. The sample shall:

- 6.10.1 Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 0.8 mm (1/32 inch) shrinkage or expansion.
- 6.10.2 Where more than one panel of a color is measured, the coefficient of retro-reflection shall be the average of all determinations.

| Table E | | | | | |
|---|-----------------|--|----------------|---|--------------------------------|
| Minimum Coefficient of Retro-reflection and Florescence Luminance Factor (All measurements shall be made after cleaning according to manufacturer's recommendations) | | | | | |
| Color | Warranty Period | Minimum Coefficient of Retro-reflection (R _A) at -4° Entrance Angle cd/lux/m ² | | Minimum Fluorescence Luminance Factor % | Minimum Total Luminance Factor |
| | | Observation Angle | R _A | Y _F | Y |
| Fluorescent Yellow | 7 Years | 0.2° | 165 | 20% | 35% |
| | | 1.0° | 30 | | |

6.11 Optical Stability. Three pieces of retro-reflective sheeting applied to test panels and conditioned as in Section 5.1 shall each first have their photo-metric properties characterized by measuring the coefficients of retro-reflection according to the provisions in Section 6.3 at all test geometries shown in Table C. These panels shall then be exposed in an air circulating oven at 170 ± 5°F (77± 3°C) for a period of 24 hours. After exposure the panels shall be allowed to condition according to the provisions of Section 5.1. These panels will again be characterized for photo-metric properties by measuring the coefficients of retro-reflection according to the provisions of Section 6.3 at all test geometries measured before exposure.

The coefficients of retro-reflection measured after exposure shall be between 85% and 115% of the values measured before exposure for each of the three samples.

6.12 Resistance to Corrosion. The retro-reflective sheeting applied to a test panel and conditioned as in 5.1, shall show no loss of adhesion, appreciable discoloration or corrosion and after cleaning shall retain a minimum of 80% of the original coefficient of retro-reflection when measured at 0.2° observation, -4° entrance and 0° rotation angles after 1000 hours exposure to a 5% concentration salt spray at 35°C (95°F) when tested in accordance with ASTM B 117.

6.13 General Characteristics and Packaging. The retro-reflective sheeting as supplied shall be of good appearance, free from ragged edges, cracks and extraneous

materials, and shall be furnished in either rolls or sheets. When furnished in continuous rolls, the average number of splices shall not be more than 3 per 50 yards (45.7 meters) of material with a maximum of 4 pieces in any 50 yard (45.7 meters) length. Splices shall be butted and shall be suitable for continuous application as furnished. When furnished as cut sheets or sign faces, the sheeting shall be packaged flat in accordance with commercially accepted standards. The sheeting shall be packed snugly in corrugated fiberboard cartons, in accordance with commercially accepted standards. Each carton shall clearly stipulate the brand, quantity, size, lot or run number and color. Stored under normal conditions the retro-reflective sheeting as furnished shall be suitable for use for a minimum period of one year.

7.0 Sheeting Manufacturer's Warranty

7.1 Certification. The sheeting manufacturer shall, upon request, submit with each lot or shipment, a certification that states that the material supplied will meet all of the requirements listed herein.

7.2.1 If the sign deteriorates due to natural causes to the extent that:

- (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by a driver with normal vision; or
- (2) the coefficient of retro-reflection, after cleaning, is less than the minimums specified in Table E; or
- (3) the fluorescence luminance factor after cleaning, is less than the minimums specified in Tables E; or
- (4) the daytime chromaticity, after cleaning, falls outside the limits specified in Table A; or
- (5) the nighttime chromaticity, after cleaning, falls outside the limits specified in Table D.

7.2.2 Natural causes include effects of exposure to weather. Natural causes exclude (without limitation) damage from exposure to chemicals, abrasion and other mechanical damage from fasteners used to mount the sign, collisions or mishandling.

7.3 Sheeting Manufacturer's Replacement Obligation.

7.3.1 Where it can be shown that the retro-reflective sheeting fails to conform to the performance requirements of Section 7.2, the sheeting manufacturer's sole responsibility and purchaser's and user's exclusive remedy shall be:

7.3.1.1 If the failure occurs within the first 5 years from the date of fabrication, the sheeting manufacturer shall, at its expense, restore the sign surface to its original effectiveness.

7.3.1.2 If the failure occurs from the 6th or the 7th year from the date of fabrication, the sheeting manufacturer shall furnish the necessary amount of sheeting to restore the sign surface to its original effectiveness.

- 7.3.1.3 Replacement sheeting shall carry the unexpired warranty of the sheeting it replaces.
 - 7.4 Process Inks. The manufacturer of the sheeting shall furnish at no additional cost the process inks, clears and thinners recommended for the sheeting to meet the performance requirements of this specification, and shall further be responsible for technical assistance in the use of these inks in accordance with section 8.
 - 7.5 Slip Sheet. Slip sheet paper, if recommended by the sheeting manufacturer for sheeting surface protection or for use in packing, storage or shipping finished signs, shall be furnished in rolls by the manufacturer at no additional charge, in at least equal dimension (square meters) and in the same widths as the sheeting supplied.
 - 7.6 Washers. Washers, if recommended by the sheeting manufacturer to protect the sign surface from damage by bolts or other fasteners, shall be furnished by the manufacturer at no additional charge.
- 8.0 Government Using Agency Obligation. The using agency shall be responsible for requiring the dating of all signs at the time of fabrication with the fabrication date so that the start of the warranty period can be determined. In the event of claims made under the warranty the agency shall notify the sheeting manufacturer of the failure within a reasonable time of the failure, provide reasonable information requested by the sheeting manufacturer and permit the manufacturer to verify the cause of the failure.
- 9.0 Technical Assistance Requirements.
 - 9.1 Instruction and Training.
 - 9.1.1 The manufacturer supplying the sheeting requirements shall provide the services of a qualified technician for instruction and training at the primary sign manufacturing facility designated by the agency. This instruction shall be available on a quarterly basis at no additional cost, and shall include but not be limited to, training films, material application, equipment operation, silk screening techniques, packaging, storage and other proven sign shop practices as they apply to the reflective sheeting supplied by the manufacturer, and to assure that the resulting signs can comply with the applicable specifications.
 - 9.1.2 Additional on-site technical assistance by the manufacturer supplying the retro-reflective sheeting shall be provided at each of the sign shops designated in the bid invitation. This assistance will be provided at least once during each quarter of sign production, if required.
 - 9.2 Equipment. The manufacturer supplying the retro-reflective sheeting requirements shall provide service for sheeting application equipment of their manufacture, certify that trained personnel will be available on 72 hours notice to render such service, and shall stock authorized parts for their sheeting application equipment. "Service" is understood to mean the capability of calibration and trouble shooting, as well as the training and retraining of personnel as required.
 - 9.3 Compliance. Failure to comply with the requirements and schedules of 9.1 and 9.2 shall be cause for cancellation of contract.

- 10.0 Patented Devices, Materials and Processes. Seller will pay any damages, costs or fines resulting from any claims against the agency for infringement or alleged infringement of third party patents by product supplied by Seller under this specification. The costs paid by Seller shall include legal and court costs deemed reasonably necessary by counsel for the agency in defending against such claims.
- 11.0 Performance History
- 11.1 The sheeting manufacturer shall provide, upon request, accelerated outdoor weathering test data showing that representative production materials of the type to be supplied can meet the requirements for 36 months of accelerated outdoor weathering described in Section 6.10.
- 11.2 Representative production materials of the type to be supplied shall have been submitted for testing by an independent agency, such as AASHTO's National Transportation Product Evaluation Program (NTPEP), prior to approval for use.
- 11.3 The data collection shall have been completed no more than 5 years prior to the offer.

ELECTRONIC CUTABLE FILMS (EC FILM) TO BE USED ON RETROFLECTIVE SHEETING

- 1.0 SCOPE. This document covers flexible, transparent, durable films designed to be applied to retro-reflective materials for the creation of traffic control signs and devices.
- 2.0 APPLICABLE DOCUMENTS. The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:
- 2.1 ASTM STANDARDS
- 2.1.1 B 209 Specification for Aluminum and Aluminum Alloy Sheet and Plate
- 2.1.2 D 523 Standard Method for Test for Specular Gloss
- 2.1.3 D 4956 Standard Specification for Retro-reflective Sheeting for Traffic
- 2.1.4 E 284 Standard Definition of Terms Relating to Appearance of Materials
- 2.1.5 E 308 Computing the Colors of Objects by Using the CLE System
- 2.1.6 E 810 Standard Test Method for Coefficient of Retro-reflection of Retro-reflective Sheeting
- 2.1.7 E 1164 Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation.
- 2.2 CIE Publication Number 39-2, Recommendation for Surface Colours for Visual Signaling.
- 2.3 FP-92 Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects
- 3.0 **DESCRIPTION.** Electronic cutable films consist of durable, transparent, colored acrylic films coated with a transparent pressure sensitive adhesive protected by a removable liner. The films are designed to be cut on knife over roll (sprocket fed or friction fed) and flat bed electronic cutting machines. The films shall be available in standard traffic colors, be dimensionally stable, and be designed to optimally cut, weed, lift, and transfer. Use of electronic cutable films will not require the using agency to release any volatile organic compounds.

4.0 TEST METHODS

- 4.1 TEST CONDITIONS. Unless otherwise specified herein, all applied and unapplied test samples and specimens shall be conditioned at the standard conditions of $73 \pm 3^{\circ}$ F ($23 \pm 1.5^{\circ}$ C) and $50 \pm 5\%$ relative humidity for 24 hours prior to testing.
- 4.2 TEST PANELS. Unless otherwise specified herein, when tests are to be performed using test panels, the specimens of retro-reflective and/or overlay film(s) shall be applied to smooth aluminum cut from ASTM B-209 Alloy 5052-H36, 5052-H38, 5154-H38, or 6061-T6 sheets on 0.020 inch (0.051 cm), 0.040 inch (0.102 cm), or 0.063 inch (0.160 cm) thickness. The aluminum shall be degreased and lightly acid etched before the specimens are applied. The specimens shall be applied in accordance with the recommendations of the reflective sheeting and electronic cuttable film manufacturer(s).

5.0 PHYSICAL REQUIREMENTS

- 5.1 COLOR REQUIREMENTS. When electronic cuttable film is applied to retro-reflective sheeting, the resulting color of the composite sheeting will conform to Federal Specification FP-92, Section 718.01 and ASTM D 4956 or to the using agency specification for the appropriate retro-reflective sheeting to which it is applied.
- 5.1.1 COLOR TEST. Conformance to color requirements shall be determined by instrumental method in accordance with ASTM E 1164 on sheeting applied to aluminum test panels. The values shall be determined on a HunterLab Labscan 6000 0/45 Spectrocolorimeter with option CMR 559 [or approved equal 0/45 (45/0) instrument with circumferential viewing (illumination)]. Computations shall be done in accordance with ASTM E 308 for the 2° observer.
- 5.2 COEFFICIENT OF RETRO-REFLECTION, RA. When electronic cuttable film is applied to retro-reflective sheeting, the composite will conform to the percentage retained of the minimum coefficient or retro-reflection specified by the using agency and the manufacturer for the retro-reflective sheeting when the retro-reflective sheeting is screen processed. The coefficient of retro-reflective shall be determined in accordance with ASTM E 810.
- 5.2.1 UNITS. Coefficients of retro-reflection RA shall be specified in units of candelas per foot candle per square foot (candelas per lux per square meter).
- 5.2.2 The observation angles shall be 0.2 and 0.5 degrees unless otherwise specified.
- 5.2.3 The entrance angles shall be -4 and 30 degrees unless otherwise specified.
- 5.3.4 Retro-reflective sheeting with datum marks shall be tested in the orientation specified by the manufacturer. If no datum mark is supplied, the sheeting shall be rotated to determine the minimum **RA** which shall be reported without averaging.

- 5.3 SPECULAR GLOSS. The electronic cutable film shall have an 85° specular gloss of not less than 50 when tested in accordance with ASTM D 523.
- 5.4 PROCESSING AND CUTTABILITY. The electronic cutable film shall permit cutting, weeding, masking with transfer tape, lifting, and application to retro-reflective sheeting when used in accordance with manufacturer's recommendations at temperatures between 65° and 95° F (18.3° and 35.°0°C) and relative humidities between 30% and 70%. The film shall lay flat with minimal edge curl and be dimensionally stable.
- 5.5 ADHESIVE LINER. The protective liner attached to the adhesive shall be removable by peeling without soaking in water or other solutions, without breaking, tearing, or removing any adhesive from the electronic cutable film. The liner shall have a controlled release from the adhesive coated film sufficient to allow cutting without the film popping off from the liner while still allowing the liner to easily be peeled from the film. The liner shall be a clear, synthetic liner.
- 5.5.1 Film with punched edges for use on sprocket fed knife over roll cutters shall be edge scored and weeded to remove film in the punched area as a means of eliminating adhesive build up on the sprockets.
- 5.6 Resistance to Accelerated Outdoor Weathering. When electronic cutable film is applied to retro-reflective sheeting, the surface of the film shall be weather resistant and show no appreciable cracking, blistering, crazing, or dimensional change after 3 years on AASHTO's National Transportation Product Evaluation Program (NTPEP) with unprotected outdoor exposure. Inclined 45° from the horizontal facing the equator. Following weather exposure, panels shall be washed in a 5% HC 1 solution for 45 seconds, rinsed thoroughly with clean water, blotted dry with a soft clean cloth and brought to equilibrium at standard conditions. After cleaning, the coefficient of retro-reflection shall not be less than the value specified by the using agency for the retro-reflective sheeting when the retro-reflective sheeting is screen processed.
- 5.6.1 Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 1/32 inch (0.08 cm) shrinkage or expansion.
- 5.6.2 Show "good" color fastness or better when tested as in 5.7.
- 5.6.3 Retained reflectivity shall be the same as the using agency specification for screen processed retro-reflective sheeting of the type being tested.
- 5.6.4 The electronic cutable film shall not be removable from the retro-reflective sheeting without damage. Retro-reflective performance measurements made after weather exposure shall be made only at angles of 0.2° observation and -4° entrance. Where

more than one panel of a color is measured, the coefficient of retro-reflection shall be the average of all determinations.

- 5.7 COLORFASTNESS. One specimen, exposed and prepared as specified in 5.6 shall be wet out with a mild detergent and water solution and compared with a similarly treated unexposed specimen under natural (North sky) daylight or artificial daylight having a color temperature of 7600°K. The colorfastness shall be evaluated as follows:
- | | |
|-----------|---|
| Excellent | no perceptible change in color. |
| Good | perceptible but no appreciable change in color. |
| Fair | appreciable change in color. |

Appreciable change in color means a change that is immediately noticeable in comparing the exposed

- specimen with the original comparison specimen. If closer inspection or a change of angle of light is required to make apparent a slight change in color, the change is not appreciable.

5.8 GENERAL CHARACTERISTICS PACKAGING

- 5.8.1 Roll Goods. When supplied as roll goods, the electronic cutable film shall be of good appearance, free from ragged edges, cracks and extraneous materials. The maximum number of splices in each roll shall be three per 50 yards of material. Splices shall be butted. The sheeting shall be packed snugly in corrugated fiberboard cartons, in accordance with commercially accepted standards. Each carton shall clearly stipulate the brand, quantity, size, lot or run number, and color. Stored under normal conditions the electronic cutable film as furnished shall be suitable for use for a minimum period of one year.
- 5.8.2 Sign Faces. When supplied as a finished sign face or mounted sign, the sign face, made of electronic cutable film and retro-reflective sheeting, shall comply with the appearance, specification, and good workmanship designated by the using agency for sign faces constructed of screen processed retro-reflective sheeting of the same type.

6.0 PERFORMANCE REQUIREMENTS AND OBLIGATIONS

- 6.1 CERTIFICATION. The film manufacturer shall, upon request, submit with each lot of shipment, a certification which states that the material supplied will meet all of the requirements listed herein.
- 6.2 FIELD PERFORMANCE REQUIREMENTS. The electronic cutable film applied to retro-reflective sheeting, both materials applied in accordance with the manufacturer's recommendations, shall as a composite perform with the same effective performance life as the using agency specifies for that type of retro-reflective sheeting when screen processed. The composite sign will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that: (1) the sign is ineffective for its intended

purpose when viewed from a moving vehicle under normal day and night driving conditions; or (2) the coefficient of retro-reflection is less than the minimums specified by the using agency for the retro-reflective sheeting when screen processed.

6.3 ELECTRONIC FILM MANUFACTURER'S REPLACEMENT OBLIGATION. Where it can be shown that retro-reflective traffic signs with electronic cuttable film supplied and used according to the film manufacturer's recommendations have not met the performance requirements of Section 6.2, the film manufacturer shall cover restoration costs as provided in the using agency specification for the retro-reflective sheeting when screen processed.

6.4 GOVERNMENT USING AGENCY OBLIGATION. The using agency shall be responsible for requiring dating of all signs at the time of application. That date constitutes the start of the field performance obligation period.

7.0 TECHNICAL ASSISTANCE REQUIREMENTS

7.1 INSTRUCTION AND TRAINING. The manufacturer supplying the electronic cuttable film requirement shall provide the services of a qualified technician for instruction and training at the primary sign manufacturing facility designated by the agency. This instruction shall be available on a quarterly basis at no additional cost, and shall include but not be limited to, training films, material application, equipment operation, packaging, storage and other proven sign shop practices as they apply to the electronic cuttable film supplied by the manufacturer, and to assure that the resulting signs can comply with the applicable specifications. Additional on-site technical assistance by the manufacturer supplying the electronic cuttable film shall be provided at each of the sign shops designated in the bid invitation. This assistance will be provided at least once each quarter of sign production, if required.

7.2 EQUIPMENT. The manufacturer supplying the electronic cuttable film requirement shall provide service for film cutting or application equipment of their manufacture, certify that trained personnel will be available on 72 hours notice to render such service, and shall stock authorized parts for their sheeting application equipment. The manufacturer supplying the electronic cuttable film requirement shall not be required to provide service on film cutting or application equipment not of their manufacture.

7.3 COMPLIANCE. Failure to comply with the requirements and schedules of 7.1 and 7.2 shall be cause for cancellation of contract.

8.0 PATENTED DEVICES, MATERIALS, AND PROCESSES

Seller will pay any damages, costs or fines resulting from any claims against City of Tulsa for infringement of third party patents by product supplied by Seller under this specification. The costs paid by Seller shall include legal and court costs deemed reasonably necessary by

counsel for
City of Tulsa in defending against such claims.

ALTERING BIDS:

Bids cannot be altered or amended after submission deadline. Any interlineation, alteration, or erasure made before opening time and date must be initialed by the signer of the bid, guaranteeing authenticity. Bids must be submitted in ink or typewritten. Penciling will not be accepted.

PRICING:

Bid prices, unless otherwise specified, must be net, including transportation and handling charges fully prepaid by vendor to destination and subject only to cash discount for prompt payment of invoice.

BIDDER AFFIDAVITS:

Each bidder shall accompany his bid with a fully executed and notarized copy of the attached Non-Collusion Affidavit and the Interest Affidavit. Failure to do so shall be cause for rejection of the bid.

ADDENDA AND INTERPRETATIONS:

If it becomes necessary to revise any part of this bid, a written addendum will be provided to all the bidders. The City of Tulsa is not bound by any oral representations, clarifications, or changes made in the written specifications by City of Tulsa employees unless such clarification or change is provided to bidders in written addendum form from the Purchasing Division.

AWARD OF BID:

The bid shall be awarded to the firm whose proposal is responsive to the bid and is most advantageous to the City, considering the factors identified in the bid and Section 406E of Title 6, The Purchasing Ordinance set forth below:

406E. AWARD OF BID

1. Authority in the Mayor. The Mayor shall have the authority to award contracts within the purview of this chapter.
2. Lowest Secure Bidder. Contracts shall be awarded to the lowest secure bidder meeting specifications. Bid Specifications may include a point system for evaluation the lowest secure bid. In determining "lowest secure bidder", in addition to price, the following factors shall be considered:

- a. the ability, capacity and skill of the bidder to perform the contract or provide the service required;
- b. whether the bidder can perform the contract or provide the service promptly or within the time specified, without delay or interference;
- c. the character, integrity, reputation, judgment, experience and efficiency of the bidder;
- d. the quality of performance of previous contracts or services;
- e. the previous and existing compliance by the bidder with laws and ordinances relating to the contract or service;
- f. the sufficiency of the financial resources and ability of the bidder to perform the contract or provide the service;
- g. the quality, availability and adaptability of the maintenance and service for the use of the subject of the contract;
- h. the ability of the bidder to provide future maintenance and service for the use of the subject of the contract;
- i. where an earlier delivery date would be of great benefit to the requisitioning agency, the date and terms of delivery may be considered in the bid award, and
- j. the number and scope of conditions attached to the bid.
- k. if a point system has been utilized in the bid specifications, the number of points earned by the bidder.

Terms and conditions shown on page 4 apply to this transaction.