

**SUPPLEMENTAL SPECIFICATION  
REVISIONS TO STANDARD SPECIFICATION 638 – MAINTENANCE AND  
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**638-1 DESCRIPTION**

**638-1.01 Scope**

**The following paragraph is revised to read as follows:**

- d. All traffic control devices and traffic control operations shall be in accordance with the current edition of the Manual on Uniform Traffic Control Devices from the Federal Highway Administration (MUTCD-FHWA) and the Standard Drawings.

**638-2 MATERIALS**

**638-2.01 General**

**The following paragraph is revised:**

- a. All traffic control devices shall conform to the design, dimensions, materials, colors, fabrication and installation requirements specified on the plans, the “Manual de Señales de Tránsito (MST) of the DTPW, the standard drawings of the Authority, the standard specifications as may be modified by the specification and the current edition of the Manual on Uniform Traffic Control Devices from the Federal Highway Administration (MUTCD-FHWA).

**Add the following paragraph:**

- e. All traffic control devices shall have been successfully crash tested to meet the requirements of NCHRP 350 and/or been approved by the Federal Highway Administration. The Contractor shall submit the Engineer a certificate of compliance for this in a form meeting the requirement of section 106.06 of the General Provisions.

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The following articles are revised to read as follows:

**638-2.02 Construction Signs**

- a. Sign panels may be made of aluminum, galvanized steel or marine plywood. Sign posts shall be metallic as shown on standard drawings but wood supports may be used when so designed to yield when impacted by a moving vehicle. Wood posts shall be according to temporary traffic sign mounting details included in the contract documents.
- b. Reflective sheeting shall be fluorescent orange prismatic retro-reflective consisting 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.
  - (1) Physical Properties –
    - (a) Photometric - Coefficient of Retroreflection  $R_A$  - When the sheeting applied on test panels is measured in accordance with ASTM E 810, it shall have minimum coefficient of retroreflection values as shown in Table I. The rotation angle shall be as designated by the manufacturer for test purposes, the observation angles shall be 0.2 degrees and 0.5 degrees, the entrance angles (component  $B_1$ ) shall be -4 degrees and +30 degrees.

**TABLE I**  
Minimum Coefficient of Retroreflection  $R_A$   
Candelas per footcandle per square foot

Observation Angle (deg.)	Entrance Angle (deg.)	$R_A$ Orange
0.2	- 4	200
0.2	+ 30	90
0.5	- 4	80
0.5	+ 30	50

The rotation shall be as designated by the manufacturer.

- (b) Daytime Color – Color shall conform to the requirements of Table II. Daytime color and maximum spectral radiance factor

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(peak reflectance) of sheeting mounted on test panels shall be determined instrumentally in accordance with ASTM E 991. The values shall be determined on a Hunter Lab Labscan 6000 0/45 Spectrocolorimeter with option CMR 559 (or approved equal 0/45 instrument with circumferential viewing illumination). Computations shall be done in accordance with ASTM E 308 for the 2 degree 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
<u>Orange</u> (new)	.58	.416	.523	.397	.560	.360	.631	.369	28	-
<u>Orange</u> (weathered)	.58	.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 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 degrees observation and -4 degree entrance at rotation as determined by the manufacturer for test purposes. Color shall conform to the requirements of Table III.

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**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) Field Performance – Retroreflective sheeting processed and applied to sign blank materials in accordance with the sheeting manufacturer's recommendations, shall perform effectively for a minimum of 3 years. The retroreflective 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 retroreflection is less than 100 when measured at 0.2 degrees observation and -4 degree entrance. All measurements shall be made after sign cleaning according to the sheeting manufacturer's recommendations.

**638-2.03 Barricades, Drums and Cones (limited use)**

Barricades shall be constructed of wood or plastic. Drums shall be plastic with conic, round or square section, approximately 36 inches high and a minimum of 18 inches in diameter. Cones shall be used on low-volume, low-speed (40MPH or less) roadways only. Never shall be used on expressway, freeway or toll roads. They shall be a minimum of 28 inches in height with a broadened base, orange colored and shall be made of a material that can be struck without causing damage to the impacting vehicle. Barricades, drums and cones shall be marked and reflectorized in accordance with the requirements of the current edition of the Manual on Uniform Traffic Control Devices from the Federal Highway Administration (MUTCD-FHWA).

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**638-2.04 Temporary Pavement Markings**

**Add the following paragraph:**

- e. When temporary pavement markings will remain for more than fourteen (14) calendar days, thermoplastic pavement markings in conformance to the requirements of article 716-4 or preformed plastic pavement markings in conformance to the requirements of article 716-5 shall be used.

**638-2.11 Warning Lights**

Warning lights shall be of the steady burning type meeting the requirements of the current edition of the Manual on Uniform Traffic Control Devices from the Federal Highway Administration (MUTCD-FHWA).

**Add the following articles:**

**638-2.13 Portable Changeable Message Signs (PCMS) –**

- a. PCMS's shall meet all physical display and operational requirements as described in the current edition of the Manual on Uniform Traffic Control Devices from the Federal Highway Administration (MUTCD-FHWA).
- b. Display panel and housing shall comply with the following requirements:
  - (1) Shall be weather-tight.
  - (2) All nuts, bolts, washer and other fasteners shall be made of a corrosive resistant material.
  - (3) The message matrix panel background and frame for PCMS assembly shall be painted flat black according to Federal Specification TT-E-489.
  - (4) Servicing of all message matrix panel components shall be accomplished from the front of the message matrix panel.
  - (5) Each message matrix panel shall provide a glare screen for each message line to aid against sun glare.
  - (6) The display panel, when raised in the upright position, will have a minimum height of 2.1 meters from the bottom of the panel to the ground.

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- (7) The unit shall have an accessible mechanism to easily raise and lower the display assembly. A locking device shall also be provided to ensure the display panel will remain in the raised or lowered position.
  
- c. The message matrix shall comply with the following requirements:
  - (1) The PCMS message matrix shall be 2.1 meters height by 3.0 meters wide.
  - (2) The message matrix panel shall contain three separate lines. Each line shall consist of at least eight characters, equally spaced a minimum of 7.62 cm. Each character shall contain 35 pixels in a five by seven horizontal to vertical grid arrangement.
  - (3) Each message line of the PCMS shall provide for characters 33 cm wide by 45.7 cm high and variable graphic and symbol sizes to a minimum of 45.7 cm in height.
  
- d. The electrical system of the PCMS shall be solar powered and comply with the following requirements:
  - (1) The photovoltaic unit shall provide twenty one (21) days of continuous operation without sun light with a minimum of on site maintenance.
  - (2) Automatic recharging of power supply batteries shall be provided.
  - (3) The battery shall be equipped with a battery controller to prevent over charging and over discharging. An external battery level indicator shall be provided.
  - (4) The battery, controller, and power panel shall be protected from weather elements and vandalism.
  
- e. The controller shall comply with the following requirements:
  - (1) The controller and control panel shall be housed in a weather, dust and vandal proof cabinet.
  - (2) The keyboard shall be equipped with a security lockout feature to prevent unauthorized use of the controller.
  - (3) The controller shall be solid state in design and function.
  - (4) The control panel shall display a representative message that will be displayed on the sign panel.
  - (5) The flash rate shall be adjustable in the sign controller from one to ten.

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- f. Operation and Performance –
- (1) The message shall be displayed in upper case except when lower case is project specific and is allowed by the current edition of the MUTCD.
  - (2) The message matrix shall be visible from 800 meters and legible from a distance of 200 meters under both day and night conditions. Under variable level conditions the sign shall automatically adjust its light source so as to meet the 200 meters visibility requirement. The message panel shall have adjustable display rates, so that the entire message can be read at least twice at the posted highway speed.
  - (3) The control panel shall have the capability to store a minimum of fifty (50) preprogrammed messages.
  - (4) The controller in the control panel shall have a memory capable of maintaining the stored messages even during non-powered conditions.
  - (5) The controller shall allow the operator to generate additional messages on site via the keyboard.
  - (6) All messages shall be flashed or sequenced. In the sequence mode, the controller shall have the capability to sequence three lines during one cycle.

**638-2.14 Truck-Mounted Attenuators (TMAs) and Shadow Vehicles**

- a. Truck-Mounted Attenuator systems (TMA) consist of an energy absorbing component and a rear panel with a retro-reflective chevron panel and vehicle lighting system attached to a truck (shadow vehicle) using a back support assembly with an appropriate connecting mechanism. Truck-mounted attenuators shall be equipped with a system for tilting from the horizontal configuration where it has energy absorbing capacity to a vertical position on the truck when not in use. The unit shall have a mechanical locking device to secure the truck mounted attenuator energy absorbing component in the vertical upright travel position.
- b. A Trailer Mounted TMA consists of an energy absorbing mechanism attached to a specially designed trailer connected to a truck (shadow vehicle), a rear panel with a retro-reflective chevron panel and vehicle lighting system. The Trailer Mounted TMA shall be considered a TMA system for the purposes of this specification unless indicated otherwise. The Trailer Mounted TMA shall be designed for use as a trailer with different types of trucks normally used as shadow vehicles in maintenance and construction activities. The Trailer Mounted

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TMA shall provide for easy attachment and detachment from the truck, including a trailer hitch or collar specifically designed and tested for this use. The Trailer Mounted TMA shall be complying with the requirements for a TMA system as per this specification, except the requirements in article 638-2.13 (a).

- c. The Authority reserves the right to reject a certain TMA for use in certain applications based on the crash test results, past and present equipment in-service performance and any other technical limitations noted in FHWA's letter of acceptance.
- d. The Contractor shall provide TMA systems manufactured in compliance with all requirements of this specification, the manufacturer's recommendations and the most current version of the MUTCD as adopted by the Authority.
- e. The TMA rear panel shall have a standard trailer lighting system in compliance with applicable motor vehicle laws, including but not limited to brake lights, tail lights and turn signals. Lights shall be visible in both the raised and lowered positions.
- f. The Truck-Mounted Attenuator shall be no less than 84 inches wide and no more than 108 inches wide. Color of the truck-mounted attenuators shall be yellow.
- g. All mechanical and electrical components of the TMA shall be completely compatible with the shadow vehicle following the manufacturer's recommendations. The Contractor shall be responsible to comply with all safety measures as recommended by the manufacturer. The uses of third party or homemade adapters, connectors or converters are not acceptable for the purposes of this specification.
- h. Truck-mounted attenuator systems shall conform to the requirements of the National Cooperative Highway Research Program (*NCHRP*) *Report 350*. Prior to their use, the Contractor shall submit the Engineer a certificate of compliance in a form meeting the requirements of section 106.06 of the General Provisions. The certificate of compliance shall be accompanied by the following:
  - 1) TMA product catalog, manuals and specifications.
  - 2) A copy of the Federal Highway Administration acceptance letter.
  - 3) Non-reflective and retro-reflective sheeting specifications.
  - 4) A copy of the weight ticket for the shadow vehicle as indicated in the article 638-2.13 (g.).



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- i. Each TMA shall be like new. Furnish each unit with all equipment, options, and features as required by these specifications. If the TMA system is not furnished new, the Contractor shall document and demonstrate to the Engineer’s satisfaction that the system conforms to the requirements of a new system or *NCHRP 350 at the Test Level for which it was originally designed* and may be used until the end of the attenuation device's useful service life. TMA systems without retro-reflective stripes or otherwise damaged shall not be acceptable to the Authority.
- j. Truck-mounted attenuators shall comply with crash tests according to NCHRP 350 Test Level 3 or Test Level 2, as required in each case. The Authority shall require that each truck mounted attenuator complies with the following Test Level based on the posted speed limits of the road under normal conditions, before implementing the work zone. The TMA Test Level shall comply with the following speed limits:

<b>Posted Speed Limit of the road (Under normal conditions)</b>	<b>TMA Test Level required</b>
45 MPH or less	Test Level 2
50 MPH or more	Test Level 3

- k. The TMA unit shall have a chevron pattern that covers the rear face of the unit. The standard chevron pattern shall consist of stripes, alternating non-reflective black and yellow retro-reflective prismatic sheeting, slanted at 45 degrees in an inverted "V" pattern, centered on the rear of the unit. The width of the stripes shall be between 4 - 8 inches (100 - 200 millimeters). The chevron pattern shall cover a minimum of 75 percent of the rear panel area excluding the required vehicle or trailer lighting, and shall be visible to traffic at all times.
- l. Each of the stripes in the chevron pattern shall consist of factory installed flexible sheeting, capable of absorbing minor impacts without cracking. Yellow retro-reflective prismatic sheeting material shall comply with the requirements of ASTM D4956 Type VIII or Type XI. The retro-reflective prismatic sheeting shall be installed by the manufacturer and shall comply with the performance requirements of this specification. The design and placement of the stripes shall follow this specification and the most current MUTCD requirements.

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- m. The weight of the shadow vehicle shall be as recommended by the manufacturer of the TMA. The Contractor shall provide a copy of the manufacturer's recommendation to the Engineer and a copy of a weight ticket for the vehicle. The weight ticket shall contain adequate information to associate the ticket with the applicable vehicle. Additional weight may be added to the shadow vehicle to achieve the range recommended by the manufacturer of the TMA provided the total weight is within the Gross Vehicle Weight Recommendation of the shadow vehicle and is anchored to the vehicle or installed in its bed in such a way that no movement will occur during impacts.
- n. An electronic Flashing Arrow Sign complying with Supplemental Specification 638 shall be attached to the shadow vehicle or truck-mounted attenuator system as recommended by the manufacturer. The Flashing Arrow Sign installed with the TMA shall constitute a subsidiary obligation of the Contractor under the respective pay item. The use of the Flashing Arrow Sign shall be subject to the Plans, Standard Drawings and the most current version of the MUTCD as adopted by the Authority.
- o. The shadow vehicle shall have at least one rotating amber light or high-intensity amber strobe light functioning while in operation. When indicated by the Plans or by the Engineer an electronic Flashing Arrow Sign operated in the caution mode may be used in lieu of the rotating or high-intensity amber strobe light.
- p. The transmission of the shadow vehicle with the truck-mounted attenuator in use shall be in second gear, except for those with an automatic transmission, which shall be in park. The parking brake shall be applied and the front wheels aligned straight ahead when operating in the stationary mode.

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**638-3 CONSTRUCTION REQUIREMENTS**

**638-3.02 Construction Signs**

**Paragraph b. is revised to read as follows:**

- b. The number of signs indicated in the current edition of the Manual on Uniform Traffic Control Devices from the Federal Highway Administration (MUTCD-FHWA), standard drawings, and the plans are a minimum and the Engineer may require additional signs. The Contractor shall have adequate quantities of these signs on hand prior to starting construction operations for use as required.

**638-3.03 Barricades, Drums and Cones**

**Paragraph a. is revised to read as follows:**

- a. The Contractor shall furnish, erect, maintain, move, replace and remove construction barricades, drums and cones where and as indicated on the plans, the current edition of the Manual on Uniform Traffic Control Devices from the Federal Highway Administration (MUTCD-FHWA) or as directed by the Engineer.

**638-3.04 Temporary Pavement Markings**

**Add the following paragraph:**

- c. When as required by article 2.04 e. , thermoplastic or preformed plastic pavement markings are used, they shall be applied in accordance with Specification 618.

**638-3.11 Flag persons**

**Paragraph c. is revised to read as follows:**

- a. For daytime work the flagger's vest, shirt, or jacket shall be orange, yellow, yellow-green, or a fluorescent version of these colors. For nighttime work, similar outside garments shall be retro reflective. The flagmen operate in conformance with the procedures and requirements of the current edition of the Manual on Uniform Traffic Control Devices from the Federal Highway

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Administration (MUTCD-FHWA).

**Add the following articles:**

**638-3.12 Portable Changeable Message Signs (PCMS) –**

- a. When the pay item for PCMS's is included in the proposal schedule, the Contractor shall furnish, install, operate and maintain two PCMS's which shall be always available at the project.
- b. The Engineer will notify the Contractor the exact locations for the installation of the PCMS's and the messages to be displayed on the sign.
- c. The PCMS's shall be installed and be operating with the indicated messages within two hours after a written or oral request is issued by the Engineer. Failure to comply with this requirement may be cause for the assessment of liquidated damages in the amount of five hundred dollars (\$500.00) per each hour or fraction of hour of non-compliance. Liquidated damages in the same amount will be assessed for each hour or fraction of hour the PCMS's are not operating properly.

**638-3.13 Truck-Mounted Attenuators (TMAs) and Shadow Vehicles -**

- a. Shadow vehicles shall not be used for other purposes while the truck-mounted attenuator is being used. There shall be no additional devices in the bed of the shadow vehicle except the additional weight as allowed and the truck-mounted electronic Flashing Arrow Sign.
- b. The truck upon which the attenuator is to be mounted shall be fully operational. The TMA shall be installed according to manufacturer's specifications.
- c. TMA systems shall not be parked against rigid objects such as bridge piers and portable concrete barrier except as a temporary safety measure until a stationary crash cushion is installed. This use of TMAs shall be 72 hours maximum, or as shown in the Plans.

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- d. Use of the TMA system as a stationary barrier vehicle or shadow protection vehicle for mobile or stop and go operations shall comply with the MPT Plans, the manufacturer's recommendations and the Engineer's instructions in regards to the following:
  - 1) In a stationary barrier vehicle operation, the TMA shall be positioned so that traffic does not pass any other object within the protected area (i.e. equipment, personnel, and vehicles) before reaching the TMA. When the TMA is a shadow vehicle in a mobile operation, approaching traffic shall not reach or overtake any object before passing the TMA.
  - 2) The TMA shall be positioned at a prudent distance before the area to be protected or the rear of the next vehicle in the mobile array depending on the type and speed of the operation, road conditions, traffic volumes and other site conditions.
  - 3) Each TMA in use shall have an assigned driver, who must remain in the service vehicle at all times that the TMA system is in use in a mobile operation or available to reposition the TMA within a 15-minute time frame in the case of a stationary vehicle barrier operation.
- e. In the event the truck-mounted attenuator is impacted, resulting in damage that would cause the unit to be ineffective, all work requiring the use of the truck-mounted attenuator shall cease until such time that the Contractor can provide an acceptable unit as defined in the Special Provision by means of repair or replacement. The Contractor shall complete replacement or repair operations of the defective or damaged equipment within seventy-two hours after discovery or notification of a failure.
- f. The Contractor performing the work shall provide, install, remove, relocate as necessary, and maintain the TMA system throughout the duration of the project. When not in use, the Contractor is responsible to keep the TMA system away from conflict with the roadway conditions to prevent confusion of the traveling public.

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**638-4 METHOD OF MEASUREMENT**

**638-4.01**

**Add the following paragraph:**

- n. The unit of measurement for each PCMS will be by the month measured from the date the sign is available at the project site and ready for operations, as determined by the Engineer, to the date that it is indicated by the Engineer for not being necessary in the project. Periods of less than one month will be computed at the rate of 1/30 of the unit price per month for each day of use in the project.
- o. Truck-mounted attenuators (TMAs) of the type (test level, (TL)) specified in the proposal schedule will be measured by the number of hours (or fraction of an hour) of actual operation for each unit required and accepted by the Engineer and furnished by the Contractor. This shall include the shadow vehicle, the attenuator, amber or strobe lights, electric arrow panels, vehicle maintenance, driver and any other requirements established in this specification and/or indicated by the Engineer.
- p. Shadow vehicles, when required by the Maintenance of Traffic drawings or as requested by the Engineer will be measured by the number of hours (or fraction of an hour) of actual operation for each unit required and accepted by the Engineer and furnished by the Contractor. This shall include the vehicle, amber or strobe lights, vehicle maintenance, driver and any other requirements established in this specification and/or indicated by the Engineer.

**638-5 BASIS OF PAYMENT**

**638-5.01 Payment**

**The following paragraphs are revised as follows:**

- c. Any traffic control device or equipment included under this specification, that is damaged by traffic, vandalism or other cause **not attributable** to negligence on the part of the Contractor will be repaired by force account, by an agreed unit price, or will be replaced at the contract unit price when so approved by the Engineer. However, no payment will be made for required repair or replacement of traffic control devices damaged by the Contractor's

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personnel or equipment, or as a result of negligence on his part, of for normal maintenance.

- h. In the event that that the Contractor fails to maintain traffic in a satisfactory manner in accordance with the requirements of Articles 104.7, 107.08, and 107.11 of the General Provisions and of this specification, he will be assessed liquidated damages at the rates specified in Article 108.09 of the General Provisions for each day of such failure. The Engineer will notify the Contractor in writing of the effective date of the application of this penalty. This is in addition to non-payment for items that the Contractor failed to provide and maintain under the requirement of this specification.

These fines or penalties are not reimbursable and are in addition to non-payment for items that the Contractor failed to provide and maintain under the requirements of this specification.

- i. If the Contractor fails to maintain and protect traffic adequately and safely for a period of 24 hours or more, the Engineer will correct the adverse conditions by any means he deems appropriate and will deduct the cost of such corrective work from any monies due the Contractor. The cost of this work shall be in addition to the liquidated damages and nonpayment for items specified above.

**Add the following paragraph:**

- j. When a PCMS is malfunctioning or not operating for a period of time within 2 to 24 consecutive hours, a deduction in the amount of 1/30 of the contract unit price per month will be made to the payment to the contractor for said period of time remains in the project malfunctioning or not operational.

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**638-5.02**      **Pay Items** – Payment will be made under:

**Add the following pay items:**

<u><b>Pay Item</b></u>	<u><b>Pay Unit</b></u>
Portable Changeable Message Sign (PCMS) (Each Sign) .....	Month
Truck Mounted Attenuator (TMA), TL- 2 or 3 .....	Hour
Shadow Vehicle .....	Hour

**Add the following article:**

**638-5.03**      Thermoplastic pavement markings found deficient in thickness but which are accepted by the Authority according to article 618-3.02 d. (2) will be paid for at a reduced unit price as established on article 618-5.02.