X-MAS™
X-Tension™ Median Attenuator System

- Low Initial Price
- Redirective, Non-Gating
- Contractor Friendly
- Simple installation
X-MAS™ X-Tension™ Median Attenuator System

**FEATURES**

- The lowest initial price NCHRP 350 TL-3 Redirective Non-Gating crash cushion available
- Attaches directly to double faced guardrail
- Can be attached to concrete barrier with standard transitions
- Contractor friendly
- Easy to install
- No foundation required
- No backup required

**WHERE TO USE**

- Narrow medians
- Wide medians
- Gore areas

**PHYSICAL SPECIFICATIONS**

- **Length**: 12 m [40']
- **Width**: 572 mm [22.5’]
- **Height**: 813 mm [32”]
- **Weight**: 594 kg [1310 lb]
- **Test Performance Level**: NCHRP 350 TL-3

**Summary of results for test 057083311 (NCHRP 350 Test 3-31)**

- **Impact Velocity**: 99.3 km/h
- **Test No.**: 057083311
- **Test Designation**: NCHRP 350 Test 3-31
- **Name or Manufacturer**: Barrier Systems Incorporated
- **Model**: 1996 Chevrolet Silverado PHD
- **Date**: 10 May 2007
- **Speed (km/h)**: 80
- **Impact Velocity of**: 99.3 km/h

**IS A TRANSITION NEEDED TO ATTACH TO STANDARD DOUBLE SIDED GUARDRAIL?**

The X-MAS is designed to attach directly to standard double faced guardrail with no transition required.

**CAN THE X-MAS BE INSTALLED WITHOUT A FOUNDATION?**

The X-MAS is designed to be installed in-ground using standard guardrail installation equipment.

**CAN THE X-MAS BE ATTACHED TO CONCRETE BARRIER?**

The X-MAS can be attached to concrete barrier with the addition of standard transitions.

**IS THE X-MAS REUSABLE AFTER A DESIGN IMPACT?**

The X-MAS can be ordered with either wood or composite blockouts.

**Does the X-MAS use standard guardrail posts?**

All the posts are steel. The first two posts are special, all other posts are standard steel guardrail posts.

**Can the X-MAS be installed without a foundation?**

The X-MAS is designed to be installed in-ground using standard guardrail installation equipment.

The X-MAS is designed to be a sacrificial crash cushion, making it ideal for low impact locations.

**General details for the X-tension Median Attenuator System are subject to change without notice to reflect improvements and upgrades. Additional information is available from Barrier Systems, Inc.**

**DISTRIBUTED BY:**

# ???? © Barrier Systems, Inc.

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TEL. 707.374.6800  U.S. TOLL FREE 888.800.3691

WWW.BARRIERSYSTEMSINC.COM
Mr. Owen Denman, PE
President, Barrier Systems Inc.
180 River Road
Rio Vista, CA 94571-1208

Dear Mr. Denman:

Thank you for your letter of August 2, 2007, requesting the Federal Highway Administration (FHWA) acceptance of tangent, flared, and median versions of the X-Tension™ Technology End Terminals for use on the National Highway System (NHS). The original system, the X-350™ Guardrail Terminal was developed by Armorflex, Ltd., and accepted by FHWA in our July 9, 2005, letter CC-91. Barrier Systems, Inc. has since acquired the rights to use the X-350™ Guardrail technology and has developed it further. Accompanying your letter were reports of crash testing conducted by Holmes Solutions, an approved test laboratory which was formerly a facility of the University of Canterbury in Christchurch, New Zealand, and DVD video of the tests. You requested that we find the terminals acceptable for use on the NHS under the provisions of National Cooperative Highway Research Program (NCHRP) Report 350 “Recommended Procedures for the Safety Performance Evaluation of Highway Features.”

Introduction
The FHWA guidance on crash testing of roadside safety hardware is contained in a memorandum dated July 25, 1997, titled “INFORMATION: Identifying Acceptable Highway Safety Features.” The original Armorflex X350 tangent terminal for use with strong-post W-beam guardrail includes an impact head through which two anchor cables are threaded, breakaway line posts, a slider/slider bracket assembly, a cable anchor bracket, and a foundation anchor. For side impacts to the rail, tension is transferred via the cables to the foundation anchor to provide containment and redirection. For head-on and angled impacts directly at the end, friction between the cables and a convolution in the impact head dissipates crash energy. The slider/slider bracket assembly allows the first W-beam rail segment to slide back along the second segment and away from the impacting vehicle.

Your present request is for: 1) modifications to the original tangent version, 2) a flared version, and 3) a median version, using the name X-Tension™ Technology Guardrail End Terminals. The enclosed chart “National Cooperative Highway Research Program Report 350 Test Matrix – X-Tension Testing Program” details the original matrix of tests used to validate the Armorflex X350 design, a Test Requirement Analysis of the needed impacts to validate the Flared Offset Configuration and the Median Terminal, and a Component Modification Analysis.
Testing
You discussed the proposed test matrix with Mr. Nicholas Artimovich of my staff and reached agreement on the tests detailed in the enclosed testing program chart mentioned above. The following tests were conducted and the test data summary sheets are enclosed for reference:

NCHRP Report 350 test 3-30 for the flared configuration.
NCHRP Report 350 tests 3-31 and 3-32 for the median configuration.

We concur that these tests are satisfactory to show NCHRP Report 350 compliance with the following:

- The modified tangent, flared, and median configurations using either wood (CRT) or steel line posts (first two posts crimped near the ground line) as shown in the enclosed drawings.
- The tangent, flared and median configurations use a small “kit” of key components that are used in conjunction with standard W-beam guardrail, wood or composite block-outs, steel line posts or CRT wood posts and standard guardrail component hardware to make up any of the noted configurations noted in the enclosed drawings.
- The amount of offset for flared applications can be between the tangent position (no offset) and the fully flared (1.2 m offset) as tested.
- Recognition of the redirective capability of the system from the first post. Therefore, the system qualifies as a “Redirective, Non-Gating” Terminal under the definitions in NCHRP Report 350.

Findings
The results of the testing met the FHWA requirements and, therefore, the devices described in the various requests above and detailed in the enclosed drawings are acceptable for use on the NHS under the range of conditions tested, when proposed by a highway agency.

Please note the following standard provisions that apply to the FHWA letters of acceptance:

- Our acceptance is limited to the crashworthiness characteristics of the devices and does not cover their structural features, nor conformity with the Manual on Uniform Traffic Control Devices.
- Any changes that may adversely influence the crashworthiness of the device will require a new acceptance letter.
- Should the FHWA discover that the qualification testing was flawed, that in-service performance reveals unacceptable safety problems, or that the device being marketed is significantly different from the version that was crash tested, it reserves the right to modify or revoke its acceptance.
- You will be expected to supply potential users with sufficient information on design and installation requirements to ensure proper performance.
- You will be expected to certify to potential users that the hardware furnished has essentially the same chemistry, mechanical properties, and geometry as that submitted for acceptance, and that they will meet the crashworthiness requirements of FHWA and NCHRP Report 350.
To prevent misunderstanding by others, this letter of acceptance, designated as number CC-102 shall not be reproduced except in full. This letter, and the test documentation upon which this letter is based, is public information. All such letters and documentation may be reviewed at our office upon request.

The X-Tension™ products are patented devices and considered "proprietary." The use of proprietary devices specified by a highway agency for use on Federal-aid projects must meet one of the following criteria: (a) it must be supplied through competitive bidding with equally suitable unpatented items; (b) the highway agency must certify that it is essential for synchronization with existing highway facilities or that no equally suitable alternative exists or; (c) it must be used for research or for a distinctive type of construction on relatively short sections of road for experimental purposes. Our regulations concerning proprietary products are contained in Title 23, Code of Federal Regulations, Section 635.411.

This acceptance letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented device for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate device, and the FHWA is neither prepared nor required to become involved in issues concerning patent law. Patent issues, if any, are to be resolved by the applicant.

Sincerely yours,

[Signature]
George E. Rice, Jr.
Acting Director, Office of Safety Design
Office of Safety

Enclosures
### X-Tension Guardrail Terminal - Tangent Configuration (FHWA Approval Letter HAS-10/CC-91)

<table>
<thead>
<tr>
<th>Test</th>
<th>Vehicle</th>
<th>Speed</th>
<th>Angle</th>
<th>Results</th>
<th>Test Requirement Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-30</td>
<td>815.5</td>
<td>99.7</td>
<td>0</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-31</td>
<td>2025</td>
<td>99.5</td>
<td>0</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-32</td>
<td>817.5</td>
<td>101.3</td>
<td>14.6</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-33</td>
<td>1975</td>
<td>101.5</td>
<td>14.4</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-34</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>3-35</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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X-Tension Guardrail Terminal - Flared Offset Configuration

<table>
<thead>
<tr>
<th>Test</th>
<th>Vehicle</th>
<th>Speed</th>
<th>Angle</th>
<th>Results</th>
<th>Test Requirement Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-30*</td>
<td>837</td>
<td>98.7</td>
<td>0</td>
<td>Pass</td>
<td>Required - This test was modified in accordance with FHWA discussions to create the most severe impact condition. The vehicle was off the road to the side of the road and the occupant mass was moved to the inside to maximize the impact speed and potential for intrusion into the middle of the vehicle.</td>
</tr>
<tr>
<td>3-31</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3-32</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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</tr>
<tr>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3-34</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3-35</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3-37</td>
<td>1988.5</td>
<td>98.9</td>
<td>20.2</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-39</td>
<td>1988</td>
<td>98.3</td>
<td>15.8</td>
<td>Pass</td>
<td>Required</td>
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X-Tension Median Terminal

<table>
<thead>
<tr>
<th>Test</th>
<th>Vehicle</th>
<th>Speed</th>
<th>Angle</th>
<th>Results</th>
<th>Test Requirement Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-30</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Required</td>
<td>Test 3-30 demonstrates the performance of the system during frontal impacts with the greatest potential for bending the system and causing failure. Because the design does not introduce any additional energy absorbing components to the standard X-Tension (tangent or flared) system and the additional mass is minimal, Test 3-30 was determined to be unnecessary.</td>
</tr>
<tr>
<td>3-31</td>
<td>2005</td>
<td>99.3</td>
<td>0</td>
<td>Pass</td>
<td>Because the design does not introduce any additional energy absorbing components to the standard X-Tension (tangent or flared) system and the additional mass is minimal, Test 3-31 was determined to be unnecessary. However, this test was used to verify crimped posts 1 &amp; 2 and uncrimped posts 3-6 do not affect ride down acceleration.</td>
</tr>
<tr>
<td>3-32</td>
<td>843</td>
<td>103.6</td>
<td>15</td>
<td>Pass</td>
<td>Required</td>
</tr>
<tr>
<td>3-33</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Required</td>
</tr>
<tr>
<td>3-34</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3-35</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3-37</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>3-39</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* = Modified Test

### Component Modification Analysis

Analysis of changes made to components of the X-Tension system following original NCHRP 350 testing of Tangent System

<table>
<thead>
<tr>
<th>Test</th>
<th>System</th>
<th>Part No.</th>
<th>Description</th>
<th>Component Modification Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-30, 31, 32, 33, 34, 35, 37, 39</td>
<td>Tangent</td>
<td>Posts</td>
<td>All X-Tension testing on the Tangent configured system used steel wide flange posts notched at ground level. The system is approved to use timber CFT posts as well. Reference FHWA Letter HAS-10/CC-91 for system details.</td>
<td></td>
</tr>
<tr>
<td>3-30*</td>
<td>Offset</td>
<td>B061099, B061100</td>
<td>Post 1 (top), Post 2, Post 3</td>
<td>The flanges of Post 1, 2, and 3 were &quot;crimped&quot; at ground level to weaken the post for head on impacts with light vehicles. The weakened posts perform similarly to those tested during the original X-Tension Tangent testing (notched steel posts or timber CFT posts). The lateral strength of the post is equal to or stronger than what was tested in the X-Tension tangent terminal. All other posts on the system were standard wide flange axial posts, unweakened.</td>
</tr>
<tr>
<td>3-32</td>
<td>Median</td>
<td>B061099, B061100</td>
<td>Post 1 (top), Post 2</td>
<td>The flanges of Post 1, 2, and 3 were &quot;crimped&quot; near ground level as in test 3-30*. The crimping on Post 1 were lowered to allow the post to fold closer to the ground. Post 2 and Post 3 were then notched on the side of the flange to weaken the post for head on impacts with light vehicles. The modified system was tested in the Tangent system and the results were consistent with the original system.</td>
</tr>
<tr>
<td>3-33</td>
<td>Median</td>
<td>B061098</td>
<td>Post 1 (bottom)</td>
<td>The bottom receiver channel for Post 1 was modified to allow Post 1 to fold lower to the ground and reduce the possibility of interaction with the floor pan of light vehicles. The modification removed a portion of the back side of the receiver channel. The channel was made thicker and reinforced to facilitate driving the post. The modification does not affect the lateral strength of the post and only benefits the head on impacts.</td>
</tr>
<tr>
<td>3-31</td>
<td>Median</td>
<td>Posts</td>
<td>In this test, only Posts 1 and 2 were crimped and all other posts were standard wide flange steel posts unweakened. Posts used are Wide Flange Guardrail posts in accordance with Roadside Hardware Specification PWE01. The crimping were removed from Post 3 because the light car was proven to be significantly intact with post 3.</td>
<td></td>
</tr>
</tbody>
</table>
## Flared X-350 Terminal End Installation

### Test Article
- **Test Article Type:** Flared X-350 Terminal End
- **Impact Conditions**
  - Impact Velocity: 33 km/h
  - Dynamic Barrier Deflection: 0.3 m
- **General Information**
  - Test Agency: Holmes Solutions Limited
  - Test Designation: NCHRP 350 Test 330
  - Test No.: MTHS330
  - Date: 13 December 2006
  - Location: Technical Center, Amherst, MA
  - Manufacturer: AASHTO GUARDIAN with Amorox, Inc.
  - Material of Key Elements:
    - X-350 Terminal End: AASHTO 'standard' soil M147-64 (1990)
    - Production Model: 820C
  - Test Vehicle:
    - Type: 1997 Toyota Starlet
    - Model: 820C
    - Mass (kg): 873.0
    - Curb Weight: 837.0
    - Test Inertial Dummy: 912.0
    - Dummy: 75.0

### Test Article Deflections
- **Deflections:**
  - Dynamic (m):
    - Perimeter: 0.34
    - Interior: 0.38
  - Permanent (m):
    - Exterior: 0.34
    - Exterior: 0.38
  - Vehicle Damage:
    - VDS: 12-FC-5
    - CDC: 12FLZ
  - Maximum Displayable Deflection (mm):
    - Exterior: 300
    - Interior: 30
  - Post-Impact Behaviour:
    - Max. Yaw Angle (deg): 497.1
    - Max. Pitch Angle (deg): 47.0
    - Max. Roll Angle (deg): 27.7

### Impactor Values
- **Impactor Values**
  - Speed (km/h):
    - X-direction: 9.4
    - Y-direction: -0.8
    - THV (km/h):
      - X-direction: 34.9
      - Y-direction: -18.8
    - Redline Accelerations (g's):
      - X-direction: 7.0
      - Y-direction: 19.5
      - Z-direction: 1.0
      - ASI
        - X-direction: 13.0
        - Y-direction: 4.0
        - Z-direction: 7.3

### Test Article Location
- **Position at 2.75s**
- **Position at 0.56s**
  - Resting position with lateral offset of 8.8 m
Figure 3.5  Summary of results for test 057083325 (NCHRP 350 Test 3-32)
Test 057083311 (NCHRP Test 3-31)

Test Article Deflections
- Dynamic (m) .................... 1.80'
- Permanent (m) .................. 1.78'

Vehicle Damage
- Exterior
  - VDS: 12FC-5
  - CDC: 12FCEN2
- Maximum Exterior
  - Vehicle Crush (mm) ......... 400
- Interior
  - OCDI: AS0000000
- Max. Occ. Compartment
  - Deformation (mm) .......... 0.0

Post-Impact Behaviour
- Max. Yaw Angle (deg) ....... 5.3
- Max. Pitch Angle (deg) ...... -7.8
- Max Roll Angle (deg) ........ -7.1

* Deflections measured as lateral deflection of the guardrail

Figure 3.10 Summary of results for test 057083311 (NCHRP 350 Test 3-31).
ATTACH SLIDER BRACKET P/O ITEM 1 TO END OF GUARDRAIL PANEL AS SHOWN. ENSURE THAT HEX NUTS ARE AWAY FROM TRAFFIC SIDE.

SLIDE GUARDRAIL PANEL P/O ITEM 1 OVER END OF GUARDRAIL 1. SECURE IN PLACE USING HARDWARE PROVIDED. ENSURE THAT HEX NUTS ARE ON TRAFFIC SIDE.

TIGHTEN CABLE ASSEMBLIES UNTIL THEY ARE NOT VISIBLY SAGGING BETWEEN POSTS. (THERE IS NO TENSION REQUIREMENT FOR THE CABLES).

CABLE BRACKET P/O ITEM 1. ENSURE THAT HEX NUTS ARE ON INSIDE OF GUARDRAIL PANEL.

POST & BLOCKOUT P/O ITEM 4.

REMOVING ANGLED BRACKET WHEN SLIDING GUARDRAIL 1 WITH SLIDER PANEL OVER GUARDRAIL 2. REATTACH ANGLE BRACKET.

SLIDER PANEL ON TRAFFIC SIDE SLIDER BRACKET ON INSIDE OF GUARDRAIL PANEL.

PASS 2X CABLE ASSEMBLIES BETWEEN GUARDRAIL PANELS AND BLOCKOUTS.

SEE DETAIL 'C'.

REF. STRING LINE

SEE DETAIL 'D'.

OFFSET POST 3 1 1/2" AWAY FROM TRAFFIC TO MAKE IT EASIER TO PUSH GUARDRAIL WITH SLIDER PANEL OVER GUARDRAIL 2.

OFFSET POST 3 AWAY FROM TRAFFIC PER DIMENSION SHOWN.

SEE DETAIL 'A 1 & A 2'.

SEE DETAIL 'B 1 & B 2'.

SEE DETAIL 'A 1 & A 2'.

USE GUARDRAIL HARDWARE PROVIDED P/O ITEM 3 TO SECURE BLOCKOUT TO POST. GUARDRAIL IS NOT BOLTED TO THE BLOCKOUT OR POST.

PASS CABLE ASSEMBLY UNDER THE STEEL STRAP ON THE GROUND STRUT AND FORWARD THROUGH THE HOLES AT FRONT END OF GROUND STRUT. THEN PASS CABLE ASSEMBLY THROUGH LOWER HOLE IN IMPACT HEAD WELDMENT AND THROUGH FRICTION PLATE AND OUT THE BACK SIDE OF THE IMPACT HEAD (REPEAT FOR SECOND CABLE ASSEMBLY TO PASS THROUGH UPPER HOLE IN IMPACT HEAD WELDMENT).

SQUARE WASHER ON THIS SIDE. ROUND WASHER OTHER SIDE. P/O ITEM 2.

4X M20X2.5 BOLTS P/O ITEM 2.

4X RIVET NYLON TREE P/O ITEM 2.

BEGIN STANDARD HIGHWAY B BEAM GUARDRAIL.

NOTES: UNLESS OTHERWISE SPECIFIED

1. SYSTEM TO BE INSTALLED PER MANUFACTURER SPECIFICATIONS.


3. WHEN DRIVING STEEL POST, ENSURE THAT A DRIVING CAP WITH TIMBER OR PLASTIC INSERT IS USED TO PREVENT DAMAGE TO THE GALVANIZING TO THE TOP OF THE POST.
NOTES: UNLESS OTHERWISE SPECIFIED
1. X-TENSION SYSTEM TO BE INSTALLED PER MANUFACTURER INSTRUCTIONS.
2. SYSTEM SHOWN USING STEEL WIDE FLANGE POST (PWE01) WITH TIMBER BLOCKOUTS (ROUTED, PDB01B). POST 2 MUST BE A BREAKAWAY STYLE POST CRIMPED (AS SHOWN) TIMBER CRT POST, OR EQUIVALENT.
3. SYSTEM MAY ALSO USE TIMBER CRT POSTS (PDB01) WITH TIMBER BLOCKOUTS (PDB01A).
4. SYSTEM MAY ALSO USE COMPOSITE OR PLASTIC BLOCKOUTS.

X-TENSION SYSTEM TO BE INSTALLED PER MANUFACTURER INSTRUCTIONS.

SYSTEM SHOWN USING STEEL WIDE FLANGE POST (PWE01) WITH TIMBER BLOCKOUTS (ROUTED, PDB01B). POST 2 MUST BE A BREAKAWAY STYLE POST CRIMPED (AS SHOWN) TIMBER CRT POST, OR EQUIVALENT.

SYSTEM MAY ALSO USE TIMBER CRT POSTS (PDB01) WITH TIMBER BLOCKOUTS (PDB01A).

SYSTEM MAY ALSO USE COMPOSITE OR PLASTIC BLOCKOUTS.
NOTES: UNLESS OTHERWISE SPECIFIED

1. X-TENSION MEDIAN SYSTEM TO BE NON-INSTALLATION PER MANUFACTURER SPECIFICATIONS.
2. SYSTEM SHOWN USING STEEL WIDE FLANGE POST (PW601) WITH TIMBER BLOCKOUTS (ROATED, POS01a). IF STEEL WIDE FLANGE POSTS ARE USED, POST 2 MUST BE A BREAKAWAY STYLE POST CRIMPED (AS SHOWN), TIMBER OR POST, OR EQUIVALENT.
3. SYSTEM MAY ALSO USE TIMBER OR POSTS (POS02) WITH TIMBER BLOCKOUTS (POS01b).
4. SYSTEM MAY ALSO USE COMPOSITE OR PLASTIC BLOCKOUTS.