



September 17, 2008

In Reply Refer To: HSSD/CC-88B

Mr. John C. Durkos
V.P. Technical Support and Marketing
Road Systems, Inc.
3616 Howard County Airport
Big Spring, TX 79720

Dear Mr. Durkos:

This letter is in response to your request for Federal Highway Administration (FHWA) acceptance of roadside safety devices for use on the National Highway System (NHS).

Name of devices: Sequential Kinking Terminal (SKT), and
Flared Energy Absorbing Terminal (FLEAT) with 2 Breakaway Posts
Type of devices: W-Beam Guardrail Terminals
Test Level: NCHRP Report 350 Test Level 3
Testing conducted by: Midwest Roadside Safety Facility
Date of request: April 22, 2008

You requested that we find these devices 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."

Requirements

Roadside safety devices should meet the guidelines contained in the NCHRP Report 350 FHWA Memorandum "Action: Identifying Acceptable Highway Safety Features" of July 25, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

Description

The SKT and FLEAT have been successfully crash tested and accepted by the FHWA, most recently in FHWA Acceptance Letters CC-88, dated March 8, 2005, and CC-88A, dated June 1, 2008. The use of one anchor post, seven additional breakaway posts and subsequent transition to standard line posts were the same in these two w-beam guardrail terminals. Recent full scale crash tests have demonstrated that an 820C vehicle can safely ride down full strength W6x9 steel line posts. Your present request is to replace the last six breakaway posts in these terminals with these standard W6x9 line posts.

Crash Testing

In order to evaluate the safety performance of these new designs, three full-scale crash tests were conducted on the revised FLEAT terminal design. NCHRP recommends a total of up to 7 full-scale crash tests for gating guardrail terminals. We concur that only 3 of these tests are needed to verify the safety performance of the proposed new terminal designs, as summarized below.

Test 3-30 involves an 820C vehicle striking the end of the terminal at a speed of 100 km/hr with $\frac{1}{4}$ offset and an angle of 0° . Because this test may allow the small car to strike a full strength line post, it is necessary for verification of the safety performance of the new terminals. Previous testing has shown that the small car engages more guardrail posts during tests of the FLEAT than during tests of the SKT. Hence, this test should be conducted on the FLEAT terminal in order to maximize the risk of failure.

Test 3-31 involves a 2000P vehicle striking the end of the terminal at 100 km/h and 0° . Numerous full-scale crash tests have shown that the 2000P vehicle is capable of riding down full strength guardrail posts. Further, the results of test 3-30 will provide a much better indication of the consequences of a vehicle striking an unmodified line post. Thus, Test 3-31 is not necessary for evaluating the performance of the new terminal designs.

Test 3-32 requires an 820C vehicle striking the end of the terminal at 100 km/h and an angle of 15° . Historically the third post in a tangent energy absorbing terminal has not been broken during this impact. The only thing that changed upstream of post #3 from the system that was approved previously is upper post #1. However, the behavior of this post will be more thoroughly explored in test 3-30 than in test 3-32. Therefore, we concur there is no need to conduct this test.

Test 3-33 incorporates the same impact conditions as test 3-32 with a 2000P vehicle. This test is not necessary for the same reasons that Test 3-31 is not required.

Test 3-34 involves an 820C vehicle striking the terminal at its critical impact point at a speed of 100 km/h and an angle of 15° . Because the vehicle can snag on posts 3 and 4 during this impact the new terminals need to be evaluated under this test condition. The flare of the FLEAT terminal effectively increases the impact angle for this test by approximately 6° . This test should be conducted. The increased effective impact angle makes testing of the FLEAT terminal more critical than a test of the SKT.

Test 3-35 examines the safety performance of the terminal for impacts at the beginning of the length-of-need. This test involves a 2000P striking at the beginning of length-of-need. The flare on the end of the FLEAT produces a more critical impact and this test should also be conducted on this terminal.

Test 3-39 involves a 2000P vehicle impacting the midpoint of the terminal in a reverse direction at a speed of 100 km/h and an angle of 20° . As mentioned above the 2000P test vehicle has been shown to be capable of riding down a full strength line post without posing serious threats to the occupants. Hence this test is also considered to be unnecessary.

The test data summary sheets for the three recommended crash tests, FLT2P-1 (Test 3-35), FLT2P-2 (Test 3-34), and FLT2P-3 (Test 3-30) are enclosed for reference. In test FLT2P-3 there was a small hole in the floor pan caused when the nearly-stopped vehicle came to rest on the end of a guardrail post that was under the vehicle. We concur that this does not pose a significant risk to vehicle occupants. Otherwise, all occupant risk parameters of NCHRP Report 350 were within recommended guidelines. We concur that this testing shows acceptable performance for both FLEAT and SKT terminals when modified as described.

Findings

The modified FLEAT and SKT terminals described above and detailed in the enclosed drawings are acceptable for use on the NHS under the range of conditions tested, when acceptable to a highway agency.

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

- This 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, we reserve the right to modify or revoke our 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 it will meet the crashworthiness requirements of the FHWA and the NCHRP Report 350.
- To prevent misunderstanding by others, this letter of acceptance is designated as number CC-88B and shall not be reproduced except in full. This letter and the test documentation upon which it is based are public information. All such letters and documentation may be reviewed at our office upon request.
- The FLEAT and SKT end terminals are patented products and considered proprietary. If proprietary devices are specified by a highway agency for use on Federal-aid projects, except exempt, non-NHS projects, (a) they must be supplied through competitive bidding with equally suitable unpatented items; (b) the highway agency must certify that they are essential

for synchronization with the existing highway facilities or that no equally suitable alternative exists; or (c) they 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.

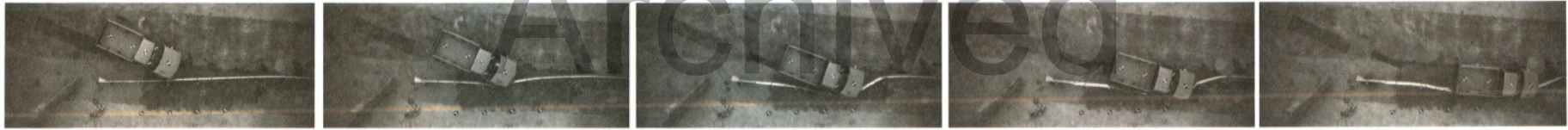
Sincerely yours,



David A. Nicol
Director, Office of Safety Design
Office of Safety

Enclosures

Archived
For
Research
and
Historical
Purposes
Only



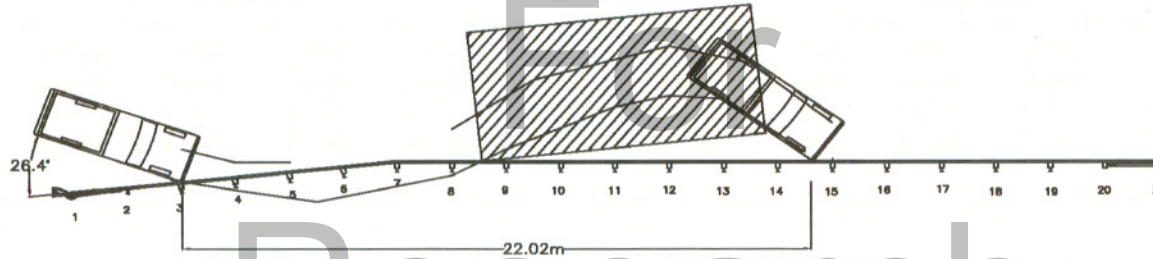
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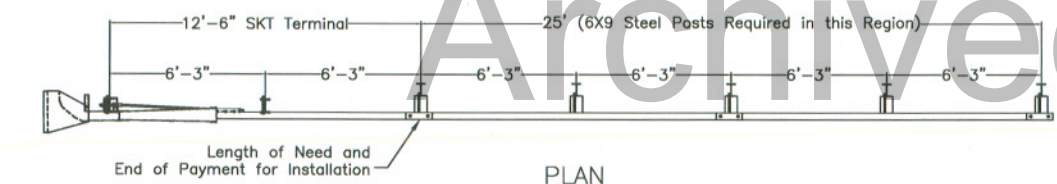
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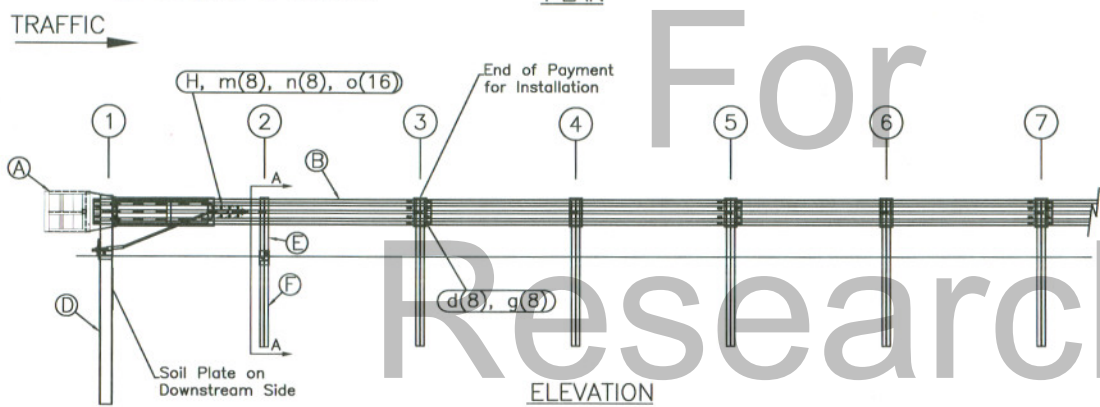
- Test Agency MwRSF
- Test Number FLT2P-1
- Date 11/29/2007
- NCHRP 350 Test Designation 3-35
- Appurtenance Two Post FLEAT End Terminal
- Total Length 38.1 m
- Key Element FLEAT impact head
- Key Element - Steel W-beam
 - Thickness 2.67 mm
 - Top Mounting Height 706 mm
- Key Element - Breakaway Steel Posts
 - Post No. 1 HP-1
 - Post No. 2 HP2A top and HP3B bottom
 - Spacing 1,905 mm
- Key Element - Steel Posts
 - Post Nos. 3-19 W152x13.4 by 1,829 mm long
 - Spacing 1,905 mm
- Key Element - Wood Spacer Blocks
 - Post Nos. 3-19 152 mm x 203 mm x 362 mm long routed
- Type of Soil Grading B-AASHTO M 147-65 (1990)
- Test Vehicle
 - Type/Designation 2000P
 - Make and Model 1991 Chevrolet C2500 pickup truck
 - Curb 2,005 kg
 - Test Inertial 2,012 kg
 - Gross Static 2,012 kg
- Impact Conditions
 - Speed 97.2 km/h
 - Angle 26.4 degrees
 - Impact Location Centerline of post no. 3
- Exit Conditions
 - Speed 43 km/h
 - Angle 28.1 degrees
 - Exit Box Criterion Pass
- Post-Impact Trajectory
 - Vehicle Stability Satisfactory
 - Stopping Distance 22.0 m downstream
- Occupant Impact Velocity
 - Longitudinal -5.33 m/s < 12 m/s
 - Lateral (not required) -3.63 m/s
- Occupant Ride Down Deceleration
 - Longitudinal -7.48 g's < 20 g's
 - Lateral (not required) -4.92 g's
- Test Article Damage Moderate
- Test Article Deflections
 - Permanent Set 1,400 mm
 - Dynamic 1,464 mm
 - Working Width 1,723 mm
- Vehicle Damage Moderate
 - VDS 01-RFQ-3
 - CDC 01-RFEW4
 - Maximum Deformation 13 mm

Summary of Test Results and Sequential Photographs, Test No. FLT2P-1

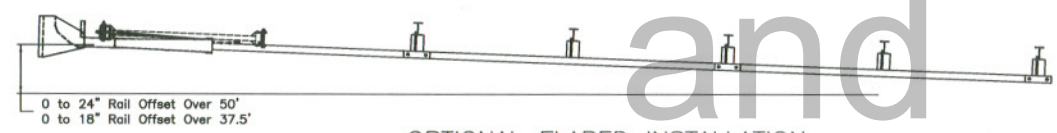
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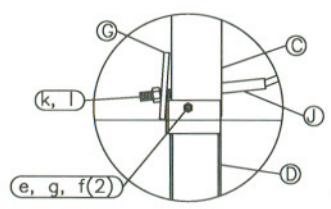
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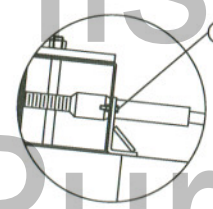
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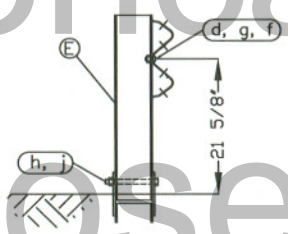
OPTIONAL FLARED INSTALLATION
25:1 maximum flare rate



Post #1 Connection Detail



Impact Head Connection Detail



SECTION A-A
Post #2

ITEM	QTY	BILL OF MATERIALS	ITEM NO.
A	1	IMPACT HEAD	S3000
B	1	W-BEAM GUARDRAIL END SECTION, 12 Co.	SF1303
C	1	FIRST POST TOP (6X6X1/4" Tube)	TPHP1A
D	1	FIRST POST BOTTOM (6" W6X15)	TPHP1B
E	1	SECOND POST ASSEMBLY TOP	HP2A
F	1	SECOND POST ASSEMBLY BOTTOM	HP3B
G	1	BEARING PLATE	E750
H	1	CABLE ANCHOR BOX	S760
J	1	BCT CABLE ANCHOR ASSEMBLY	E770

HARDWARE (ALL DIMENSIONS IN INCHES)			
a	2	5/16 x 1 HEX BOLT GRD 5	B5160104A
b	4	5/16 WASHER	W0516
c	2	5/16 HEX NUT	N0516
d	9	5/8 Dia. x 1 1/4 SPLICE BOLT (POST #2)	B580122
e	1	5/8 Dia. x 9 HEX BOLT GRD 5	B580904A
f	3	5/8 WASHER	W050
g	10	5/8 Dia. H.G.R NUT	N050
h	1	3/4 Dia. x 8 1/2 HEX BOLT GRD A449	B340854A
j	1	3/4 Dia. HEX NUT	N030
k	2	1 ANCHOR CABLE HEX NUT	N100
l	2	1 ANCHOR CABLE WASHER	W100
m	8	CABLE ANCHOR BOX SHOULDER BOLT	S858A
n	8	1/2 A325 STRUCTURAL NUT	N055A
o	16	1 1/16 OD x 9/16 ID A325 STR. WASHER	W050A

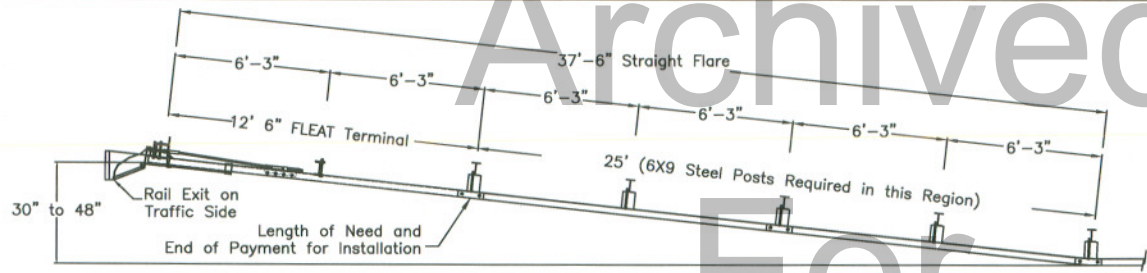
- GENERAL NOTES:
1. All bolts, nuts, cable assemblies, cable anchors and bearing plates shall be galvanized.
 2. The lower sections of the Posts 1&2 shall not protrude more than 4 in above the ground (measured along a 5' cord). Site grading may be necessary to meet this requirement.
 3. The lower sections of the hinged posts should not be driven with the upper post attached. If the post is placed in a drilled hole, the backfill material must be satisfactorily compacted to prevent settlement.
 4. When competent rock is encountered, a 10" Ø post hole, 20 in. deep cored into the rock surface may be used if approved by the engineer for posts 1&2. Granular material will be placed in the bottom of the hole, approximately 2.5" deep to provide drainage. The first two posts can be field cut to length, placed in the hole and backfilled with suitable backfill. The soil plate on post 1 may be trimmed if required.
 5. A site evaluation should be considered if there is less than 25' between the outlet side of the terminal and any adjacent driving lane.
 6. The breakaway cable assembly must be taut. A locking device (vice grips or channel lock pliers) should be used to prevent the cable from twisting when tightening nuts.



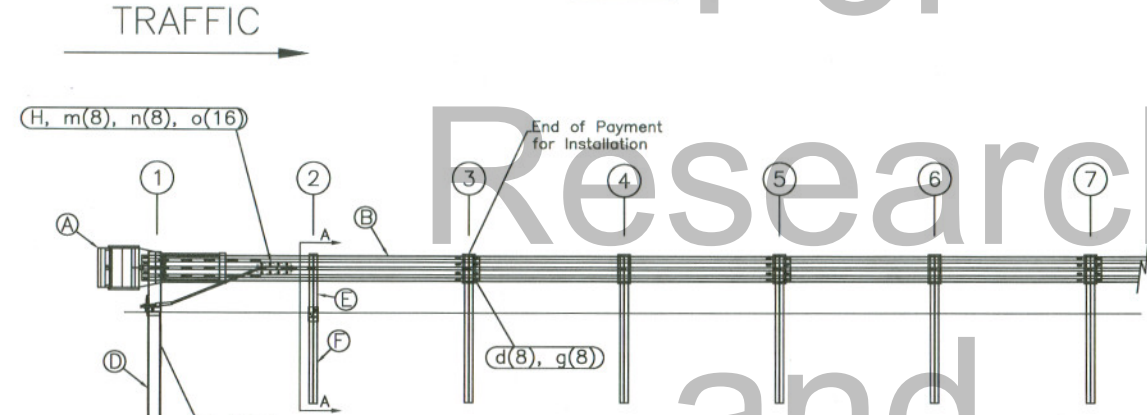
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Scale: None	Rev: 0	

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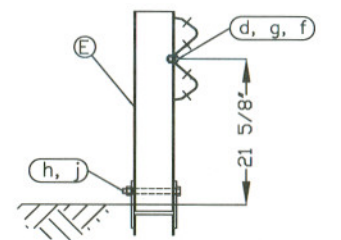
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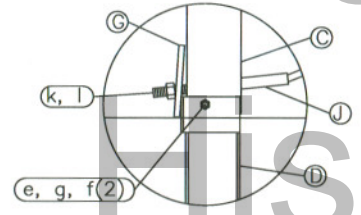
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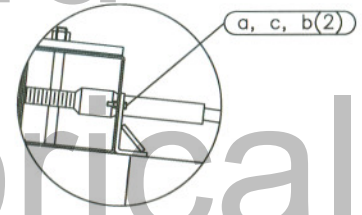
ELEVATION



SECTION A-A
Post #2



Post #1 Connection Detail



Impact Head Connection Detail

ITEM	QTY	BILL OF MATERIALS	ITEM NO.
A	1	IMPACT HEAD	F3000
B	1	W-BEAM GUARDRAIL END SECTION, 12 Ga.	SF1303
C	1	FIRST POST TOP (6X6X1/2" Tube)	TPHP1A
D	1	FIRST POST BOTTOM (6' W6X15)	TPHP1B
E	1	SECOND POST ASSEMBLY TOP	HP2A
F	1	SECOND POST ASSEMBLY BOTTOM	HP3B
G	1	BEARING PLATE	E750
H	1	CABLE ANCHOR BOX	S760
J	1	BCT CABLE ANCHOR ASSEMBLY	E770

HARDWARE (ALL DIMENSIONS IN INCHES)			
a	2	5/16 x 1 HEX BOLT GRD 5	B5160104A
b	4	5/16 WASHER	W0516
c	2	5/16 HEX NUT	N0516
d	9	5/8 Dia. x 1 1/4 SPLICE BOLT (POST #2)	B580122
e	1	5/8 Dia. x 9 HEX BOLT GRD 5	B580904A
f	3	5/8 WASHER	W050
g	10	5/8 Dia. H.G.R NUT	N050
h	1	3/4 Dia. x 8 1/2 HEX BOLT GRD A440	B340B54A
j	1	3/4 Dia. HEX NUT	N030
k	2	1 ANCHOR CABLE HEX NUT	N100
l	2	1 ANCHOR CABLE WASHER	W100
m	8	CABLE ANCHOR BOX SHOULDER BOLT	SB58A
n	8	1/2 A325 STRUCTURAL NUT	N055A
o	16	1 1/16 OD x 9/16 ID A325 STR. WASHER	W050A

- GENERAL NOTES:**
- All bolts, nuts, cable assemblies, cable anchors and bearing plates shall be galvanized.
 - The lower sections of the Posts 1&2 shall not protrude more than 4 in above the ground (measured along a 5' cord). Site grading may be necessary to meet this requirement.
 - The lower sections of the hinged posts should not be driven with the upper post attached. If the post is placed in a drilled hole, the backfill material must be satisfactorily compacted to prevent settlement.
 - When competent rock is encountered, a 10" Ø post hole, 20 in. deep cored into the rock surface may be used if approved by the engineer for posts 1&2. Granular material will be placed in the bottom of the hole, approximately 2.5" deep to provide drainage. The first two posts can be field cut to length, placed in the hole and backfilled with suitable backfill. The soil plate on post 1 may be trimmed if required.
 - The breakaway cable assembly must be taut. A locking device (vice grips or channel lock pliers) should be used to prevent the cable from twisting when tightening nuts.

RSI
Road Systems, Inc.
Big Spring, TX
Phone: 432-263-2435
or Phone: 330-346-0721

**FLEAT Terminal
Metric Height
2 Post System**

Drawing Name: **FLT2P-S** Scale: **None**

Sheet:	1
Date:	04/17/08
By:	JRR
Rev:	0

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<ul style="list-style-type: none"> ● Test Agency MwRSF ● Test Number FLT2P-3 ● Date 3/11/2008 ● NCHRP 350 Test Designation 3-30 ● Appurtenance Two Post FLEAT End Terminal ● Total Length 38.1 m ● Key Element - Steel W-beam <ul style="list-style-type: none"> Thickness 2.67 mm Top Mounting Height 706 mm ● Key Element - Breakaway Steel Posts <ul style="list-style-type: none"> Post No. 1 HP-1 Post No. 2 HP2A top and HP3B bottom Spacing 1,905 mm ● Key Element - Steel Posts <ul style="list-style-type: none"> Post Nos. 3-19 W152x13.4 by 1,829 mm long Spacing 1,905 mm ● Key Element - Wood Spacer Blocks <ul style="list-style-type: none"> Post Nos. 3-19 152 mm x 203 mm x 362 mm long routed ● Type of Soil Grading B-AASHTO M 147-65 (1990) ● Test Vehicle <ul style="list-style-type: none"> Type/Designation 820C Make and Model 2000 Chevrolet Metro Curb 832 kg Test Inertial 834 kg Gross Static 906 kg ● Impact Conditions <ul style="list-style-type: none"> Speed 96.6 km/h Angle 0.8 degrees Impact Location FLEAT End Terminal Impact Head 	<ul style="list-style-type: none"> ● Exit Conditions <ul style="list-style-type: none"> Speed n/a Angle n/a Exit Box Criterion n/a ● Post-Impact Trajectory <ul style="list-style-type: none"> Vehicle Stability Satisfactory Stopping Distance 5.26 m downstream ● Occupant Impact Velocity (EDR-3) <ul style="list-style-type: none"> Longitudinal -7.71 m/s < 12 m/s Lateral 0.08 m/s < 12 m/s ● Occupant Ride Down Deceleration (EDR-3) <ul style="list-style-type: none"> Longitudinal -13.25 g's < 20 g's Lateral -5.16 g's < 20 g's ● Occupant Impact Velocity (DTS) <ul style="list-style-type: none"> Longitudinal -7.60 m/s < 12 m/s Lateral 0.31 m/s < 12 m/s ● Occupant Ride Down Deceleration (DTS) <ul style="list-style-type: none"> Longitudinal -14.14 g's < 20 g's Lateral -6.26 g's < 20 g's ● Test Article Damage Moderate ● Test Article Deflections <ul style="list-style-type: none"> Permanent Set n/a Dynamic 6,998 mm Working Width 2.2 m non-traffic side by 8.7 m downstream ● Vehicle Damage <ul style="list-style-type: none"> VDS 12-FD-5 CDC 12-FDEW4 Maximum Deformation 13 mm
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Summary of Test Results and Sequential Photographs, Test No. FLT2P-3

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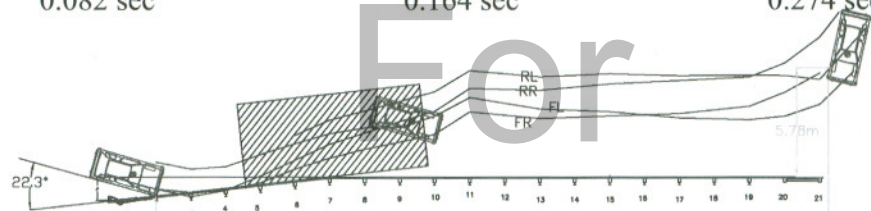
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● Test Agency	MwRSF	● Exit Conditions	
● Test Number	FLT2P-2	Speed	64.1 km/h
● Date	2/13/2008	Angle	13.5 degrees
● NCHRP 350 Test Designation	3-34	Exit Box Criterion	Pass
● Appurtenance	Two Post FLEAT End Terminal	● Post-Impact Trajectory	
● Total Length	38.1 m	Vehicle Stability	Satisfactory
● Key Element - Steel W-beam		Stopping Distance	36.6 m downstream 5.8 m traffic-side
Thickness	2.67 mm	● Occupant Impact Velocity (EDR-3)	
Top Mounting Height	706 mm	Longitudinal	-5.89 m/s < 12 m/s
● Key Element - Breakaway Steel Posts		Lateral	-5.58 m/s < 12 m/s
Post No. 1	HP-1	● Occupant Ride Down Deceleration (EDR-3)	
Post No. 2	HP2A top and HP3B bottom	Longitudinal	-7.59 g's < 20 g's
Spacing	1,905 mm	Lateral	-8.65 g's < 20 g's
● Key Element - Steel Posts		● Occupant Impact Velocity (DTS)	
Post Nos. 3-19	W152x13.4 by 1,829 mm long	Longitudinal	-5.61 m/s < 12 m/s
Spacing	1,905 mm	Lateral	-5.90 m/s < 12 m/s
● Key Element - Wood Spacer Blocks		● Occupant Ride Down Deceleration (DTS)	
Post Nos. 3-19	152 mm x 203 mm x 362 mm long routed	Longitudinal	-8.60 g's < 20 g's
● Type of Soil	Grading B-AASHTO M 147-65 (1990)	Lateral	-11.00 g's < 20 g's
● Test Vehicle		● Test Article Damage	Moderate
Type/Designation	820C	● Test Article Deflections	
Make and Model	2000 Chevrolet Metro	Permanent Set	464 mm
Curb	844 kg	Dynamic	592 mm
Test Inertial	841 kg	Working Width	804 mm
Gross Static	914 kg	● Vehicle Damage	Moderate
● Impact Conditions		VDS	1-RFQ-4
Speed	100.0 km/h	CDC	01-RDEW9
Angle	22.3 degrees	Maximum Deformation	102 mm
Impact Location	Centerline of post no. 2		

Summary of Test Results and Sequential Photographs, Test No. FLT2P-2

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