August 29, 2002

HSA-10/CC-76

Dean C. Alberson, Ph.D., P.E.
Associate Research Engineer
Texas Transportation Institute
3135 TAMUS
College Station, TX 77843-3135

Dear Dr. Alberson:

In your January 29 letter to Mr. Michael Halladay, you requested the Federal Highway Administration's acceptance of a terminal designed for use with a 3-strand cable guardrail. To support your request, you also sent copies of a Texas Transportation Institute report dated March 2002, entitled "Crash Testing and Evaluation of a New Terminal for Cable/Wire Rope Guardrail," and copies of the crash test videotapes. After staff review of the reported tests, we requested an additional test, NCHRP Report 350 test 3-30. This test was successfully conducted on February 13 and a revised report was sent to Mr. Halladay with your March 6 letter. Based on mutual agreement between our respective staffs, a decision was then made to run a second reverse-direction test (NCHRP Report 350 test 3-39) at an impact point considered to be more critical than that assumed for the original 3-39 test. Significant design changes were made before a successful test was run, the results of which were documented in a separate TTI report, dated August 2002, entitled "NCHRP Report 350 Test 3-39 with 820C Vehicle on the New Cable Terminal."

The final design consists of three proprietary Cable Release Posts (CRP posts) on 1900-mm centers. These posts are two-part posts comprised of a 900-mm long W150 x 14 upper post and a 1980-mm long W150 x 22 anchor post. Each CRP post is used to anchor one of the three wire ropes in the cable guardrail. The cables were 19-mm diameter 3 x 7 wire rope. Standard line posts (S75 x 8 x 1600) with soil plates were used for the remainder of the 106-m long test installation, except for the second 3-39 test, which used 6kg/m (4lb/ft) Marion Steel Rib-Bak U-channel posts. Either type post can be used in this terminal. The first line post (post 4) was installed 1900 mm from the third CRP post, line posts 5 through 9 were on 2000-mm centers and the remaining length of need posts were on 5000-mm centers. Design details and layout dimensions are shown in Enclosure 1. The cable barrier was installed as a median barrier with the top and bottom cables on the field side of the barrier and the center cable on the impact side. Cable heights were 520 mm, 640 mm, and 750 mm to the center of the cables (for the S75 x 8 line posts) and each cable was tensioned to 25 kN (5620 lbs) for the ambient temperature at the test site of approximately 28 degrees C. Cable heights when U-channel posts were used were 530 mm, 615 mm, and 725 mm due primarily to the locations of the pre-punched holes in these posts. From post 9, the middle cable was lowered until it was just

above the bottom cable at post 7 through post 4. Patented locking hook bolts were used throughout the terminal area to delay release of the cables in a crash. These special bolts must also be used in the terminal in place of standard J-bolts when S75 x 8 steel posts are used in lieu of the U-channel posts. Spring compensators were not used in the final design to further limit cable deflections at the terminal.

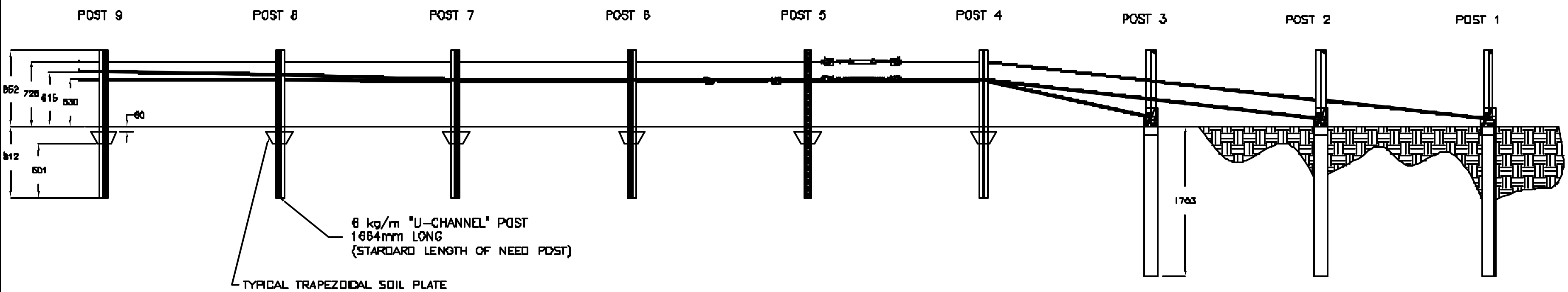
Based on staff review of the results of the five NCHRP Report 350 tests that were conducted (and summarized in Enclosure 2), I agree that tests 3-31, 3-32, and 3-33 can be waived, and that your cable guardrail terminal as described above meets the appropriate evaluation criteria for a test level 3 (TL-3) guardrail anchor. Your proprietary design may be used on the National Highway System when selected by the contracting authority under the provisions of Title 23, Code of Federal Regulations, Section 635.411. Based on the reported test conditions, the barrier length of need should be considered to begin 300 mm downstream from the first line post (post 4). This terminal may also be used to anchor a roadside cable barrier (i.e., one with all three cables on the impact side of the line posts) provided the cable heights in the terminal are adjusted to match the tested design described above.

Because this terminal has been designed to withstand cable tension significantly higher than the generic 3-strand cable guardrail, adequate anchorage must be provided for each CRP anchor post. All testing was done with these posts installed in a compacted NCHRP Report 350 strong soil. In some soils, it is assumed that foundation tubes or concrete footings may be required to establish and maintain cable tension. Cable tension must be initially set based on ambient air temperature. I assume that users of this terminal will be provided installation/maintenance guidelines that correlate proper cable tension to temperature and describe a method or methods for measuring the tension with reasonable accuracy. I would appreciate receiving a copy of such guidelines for our files when they become available.

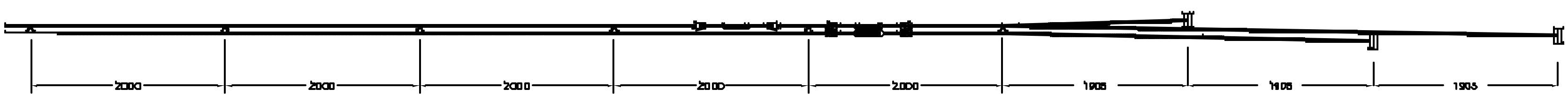
Sincerely yours,

(original signed by Janet A. Coleman)
for
Carol H. Jacoby, P.E.
Director, Office of Safety Design

2 Enclosures



ELEVATION



PLAN

The Texas A&M University System

TEXAS TRANSPORTATION INSTITUTE
COLLEGE STATION, TEXAS 77843

Revisions		
No.	Date	By
1.	6/19/02	CRM
2.	6/20/02	BAS
3.	6/21/02	CRM
4.	7/8/02	CRM
5.		

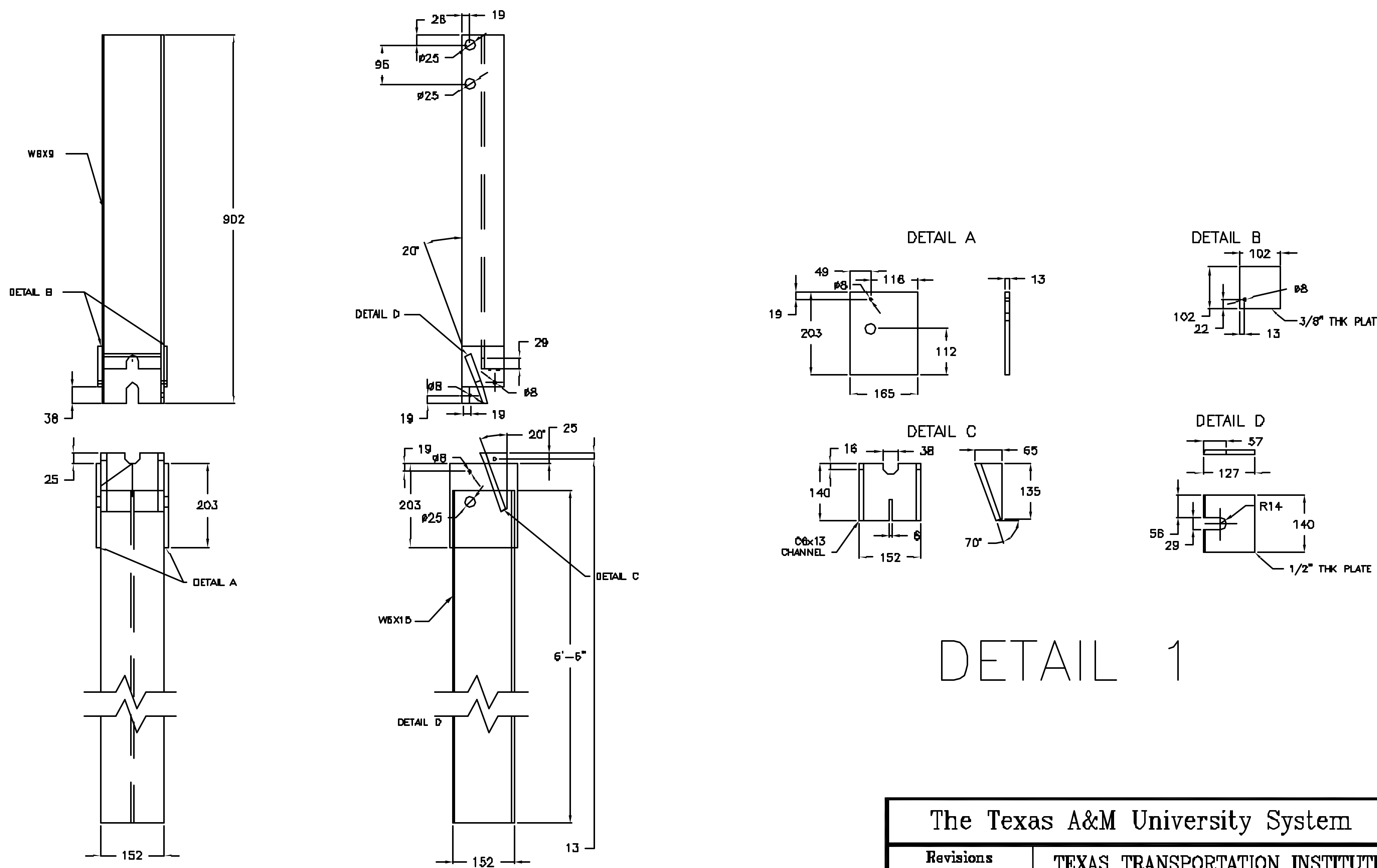
Project No.	Date	Drawn By	Scale
220502	5/02	CRM	

CABLE GUARDRAIL TERMINAL TEST INSTALLATION

Sheet No. 2 of 5

T:\2001-2002\220502\Test 7\AutoCad Drawings\Cable Rail 7-8-02.dwg

Aug 28, 2002 - 10:10am



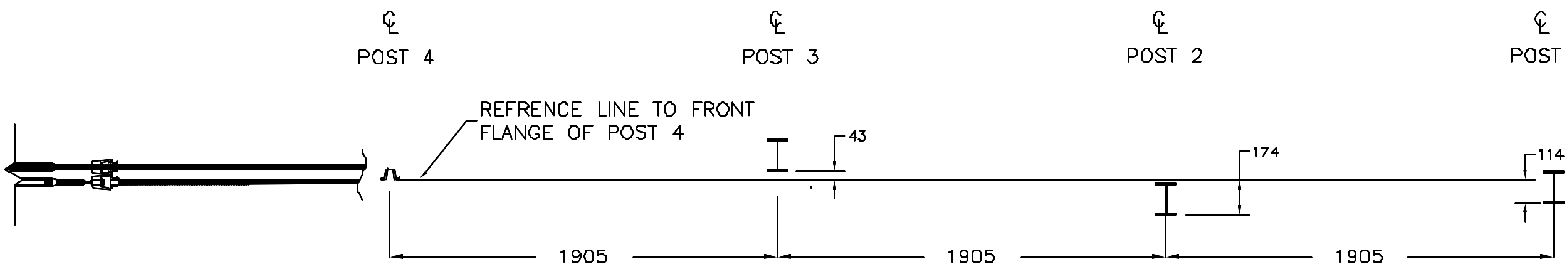
DETAIL 1

The Texas A&M University System				
TEXAS TRANSPORTATION INSTITUTE COLLEGE STATION, TEXAS 77843				
Project No. 220502	Date 11/01	Drawn By BAS	Scale	
STEEL BREAKAWAY CABLE GUARDRAIL TEST INSTALLATION			Sheet No. 3 of 5	

Revisions		
No.	Date	By
1.		
2.		
3.		
4.		
5.		

T:\2001-2002\220502\Test04\AutoCad Drawings\cable rail (02-13-02).dwg

Feb 22, 2002 - 8:08am



CRP POST POSITIONS

T:\2001-2002\220502\Test 7\AutoCad Drawings\Cable Rail 7-B-02.dwg

The Texas A&M University System

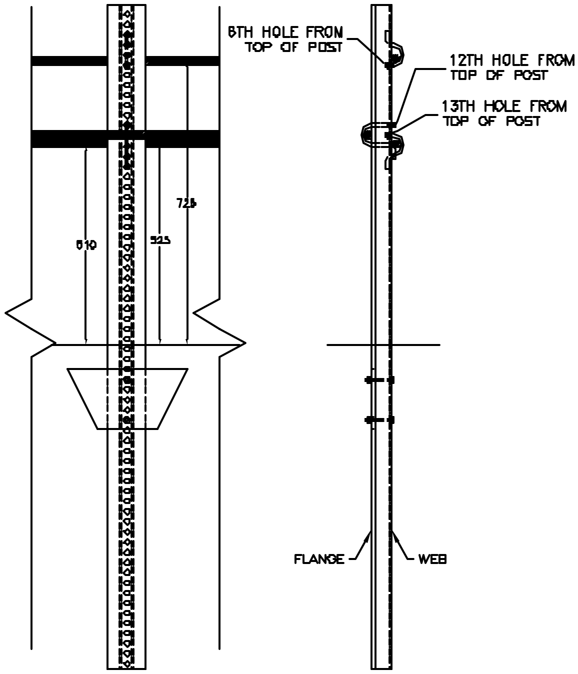
TEXAS TRANSPORTATION INSTITUTE
COLLEGE STATION, TEXAS 77843

Revisions		
No.	Date	By
1.	6/19/02	CRM
2.	7/8/02	CRM
3.	7/30/02	CRM
4.		
5.		

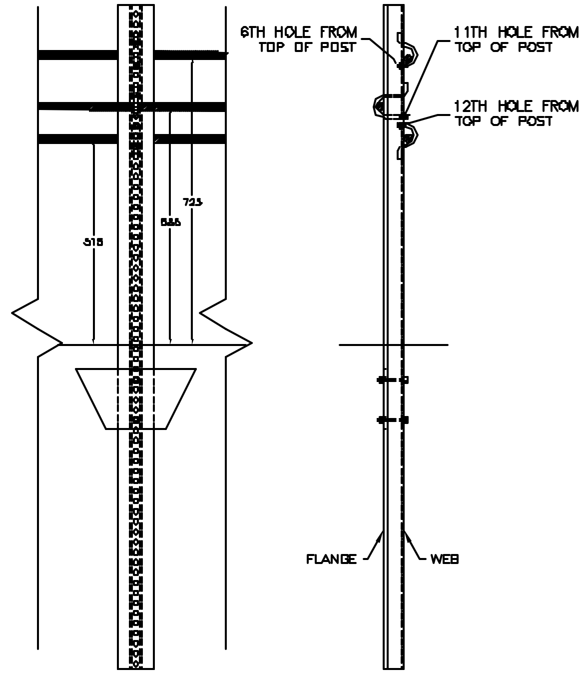
Project No.	Date	Drawn By	Scale
220502	5/02	CRM	

CABLE GUARDRAIL TERMINAL TEST INSTALLATION

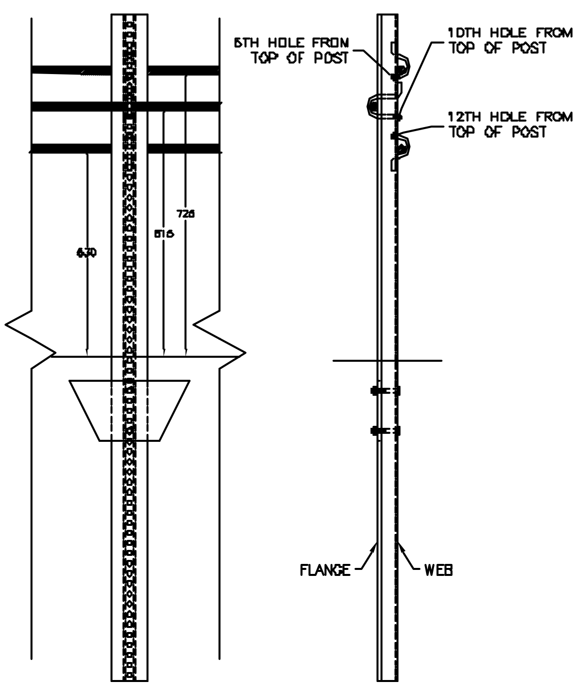
Sheet No. 4 of 5



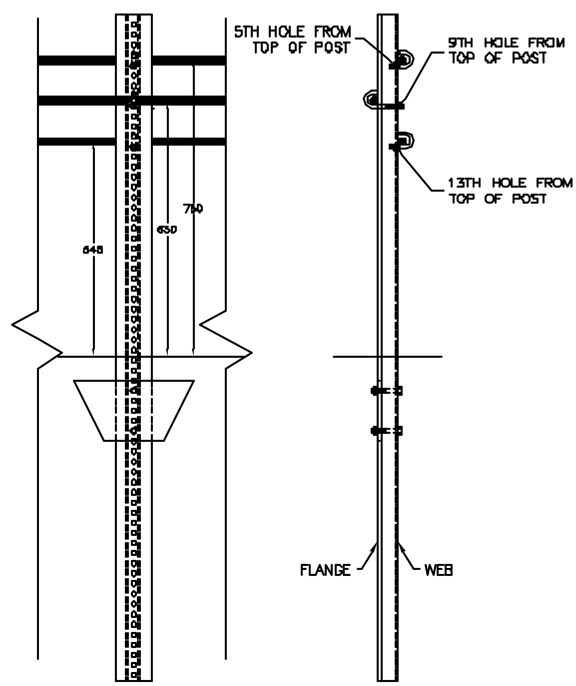
POST 4 – 7 CABLE HEIGHTS
(LOCKING HOOK BOLTS)



POST 8 CABLE HEIGHTS
(LOCKING HOOK BOLTS)



POST 9 CABLE HEIGHTS
(LOCKING HOOK BOLTS)



CABLE HEIGHTS BEYOND POST 9
(J–BOLTS)

NOTE: CABLE RAIL HEIGHTS ARE TO THE MIDDLE OF THE CABLE.

The Texas A&M University System

Revisions		
No.	Date	By
1.	7/8/02	CRM
2.		
3.		
4.		
5.		

TEXAS TRANSPORTATION INSTITUTE
COLLEGE STATION, TEXAS 77843

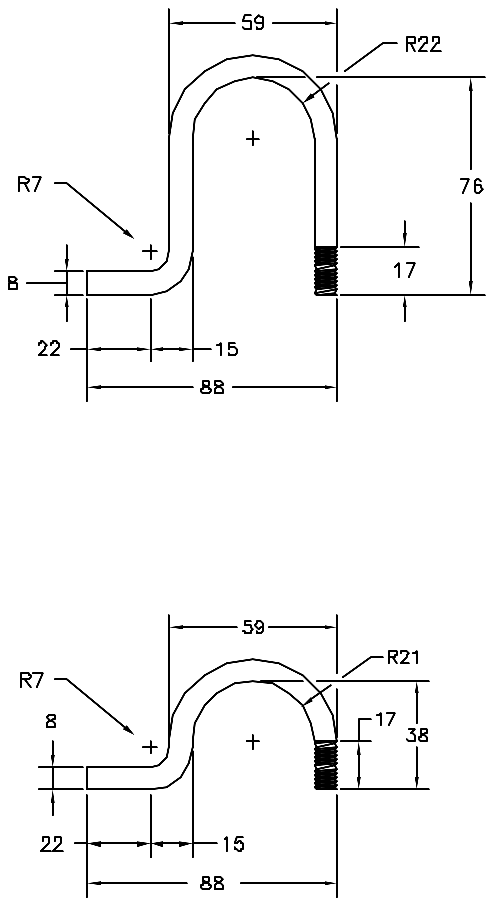
Project No.	Date	Drawn By	Scale
220502	06/02	CRM	

CABLE GUARDRAIL TERMINAL TEST INSTALLATION

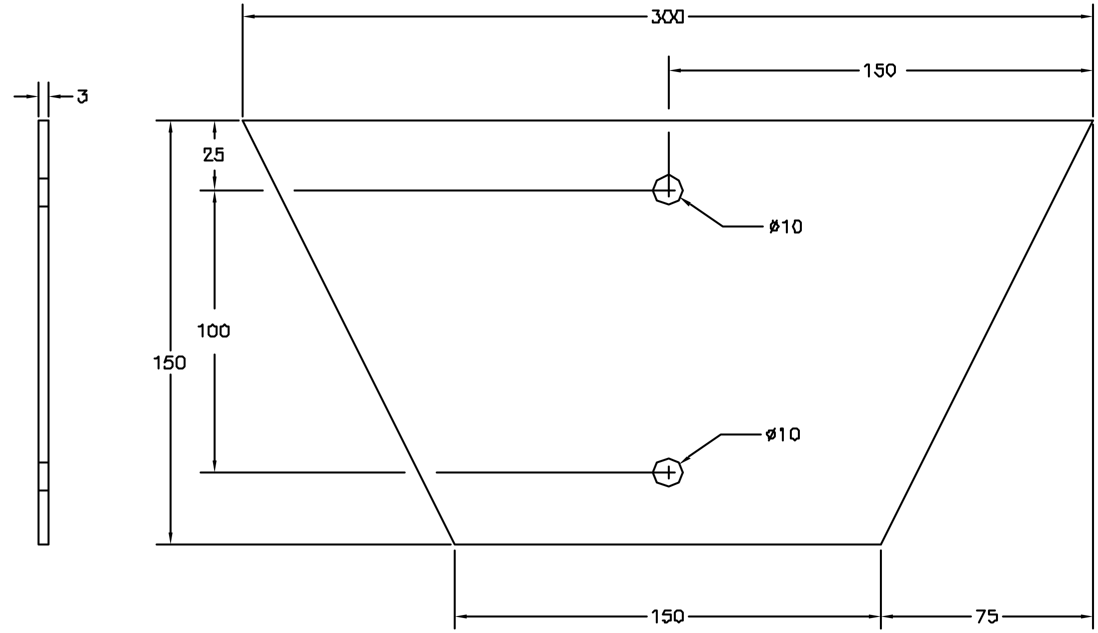
Sheet No. 3 of 5

T:\2001-2002\220502\Test 7\AutoCad Drawings\Cable Rail 7-8-02.dwg

Aug 28, 2002 – 10:11am



LOCKING HOOK BOLTS



TRAPEZOIDAL SOIL PLATE

The Texas A&M University System

TEXAS TRANSPORTATION INSTITUTE
COLLEGE STATION, TEXAS 77843

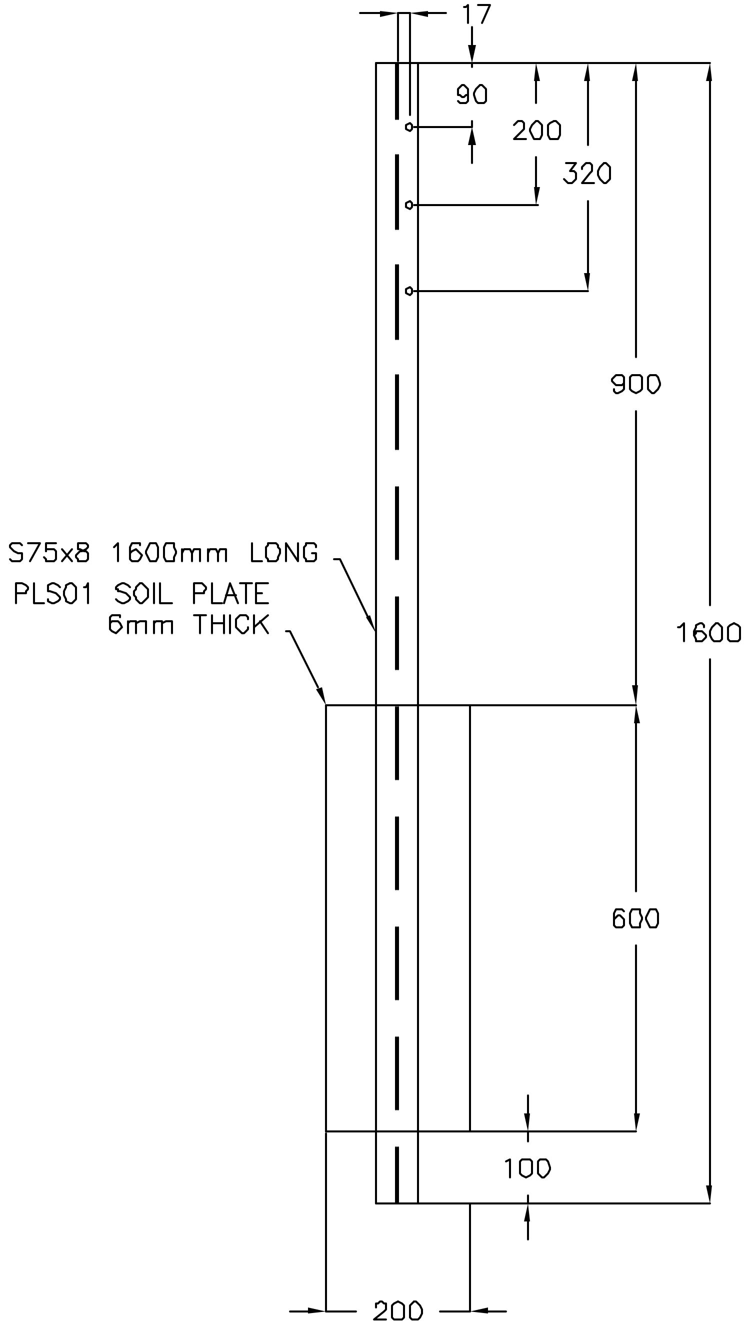
Revisions		
No.	Date	By
1.		
2.		
3.		
4.		
5.		

Project No.	Date	Drawn By	Scale
220502	7/02	CRM	

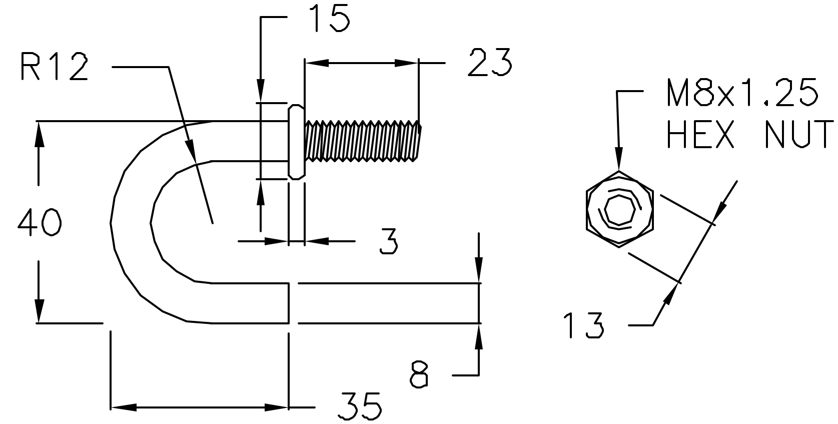
CABLE GUARDRAIL TERMINAL TEST INSTALLATION

Sheet No. 5 of 5

T:\2001-2002\220502\Test 7\AutoCad Drawings\Cable Rail 7-B-02.dwg



LINE POST DETAIL



SHOULDERED CABLE HOOK BOLT

The Texas A&M University System						
Revisions			TEXAS TRANSPORTATION INSTITUTE COLLEGE STATION, TEXAS 77843			
No.	Date	By				
1.			Project No. 220502	Date 11/01	Drawn By BAS	Scale
2.						
3.						
4.			STEEL BREAKAWAY CABLE GUARDRAIL TEST INSTALLATION			Sheet No. 5 of 5
5.						

Feb 22, 2002 - 8:08am

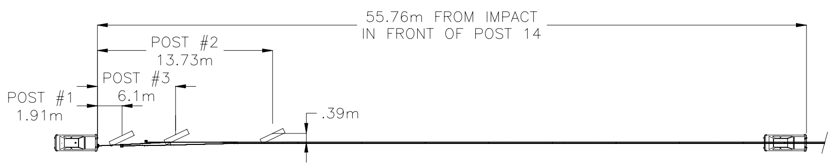
T:\2001-2002\220502\Test04\AutoCad Drawings\cable rail (02-13-02).dwg

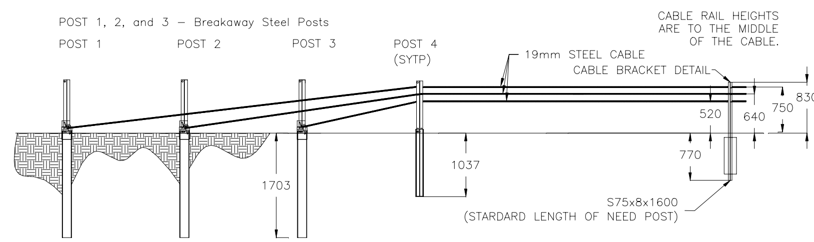
0.000 s

0.195 s

0.977 s

3.421 s





General Information	
Test Agency	Texas Transportation Institute
Test No.	220502-4
Date	02/13/02
Test Article	
Type	End Treatment
Name	New Terminal For Cable Guardrail
Installation Length (m)	106.4
Material or Key Elements	Three-Cable Guardrail System Anchored With Breakaway Steel Posts
Soil Type and Condition	Standard Soil, Dry
Test Vehicle	
Type	Production
Designation	820C
Model	1997 Geo Metro
Mass (kg)	
Curb	815
Test Inertial	820
Dummy	76
Gross Static	896

Impact Conditions	
Speed (km/h)	101.2
Angle (deg)	0.3
Exit Conditions	
Speed (km/h)	86.1
Angle (deg)	7.7
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	3.4
y-direction	0.4
THIV (km/h)	12.4
Ridedown Accelerations (g's)	
x-direction	-6.5
y-direction	2.4
PHD (g's)	6.9
ASI	0.33
Max. 0.050-s Average (g's)	
x-direction	-3.4
y-direction	0.8
z-direction	-2.4

Test Article Deflections (m)	
Dynamic	55.76
Permanent	55.76
Working Width	1.47
Vehicle Damage	
Exterior	
VDS	12FL3
CDC	12FZEW2
Maximum Exterior Vehicle Crush (mm)	320
Interior	
OCDI	FS0000000
Max. Occ. Compart. Deformation (mm)	16
Post-Impact Behavior (during 1.0 s after impact)	
Max. Yaw Angle (deg)	6.2
Max. Pitch Angle (deg)	4.8
Max. Roll Angle (deg)	-9.7

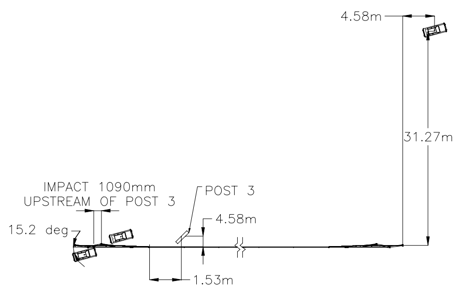
Summary of results for test 220502-4, *NCHRP Report 350* test 3-30.

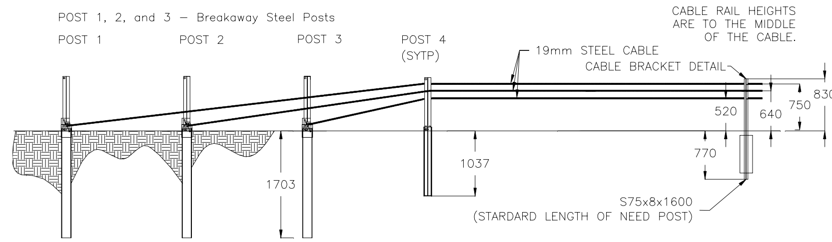
0.000 s

0.245 s

0.734 s

1.591 s



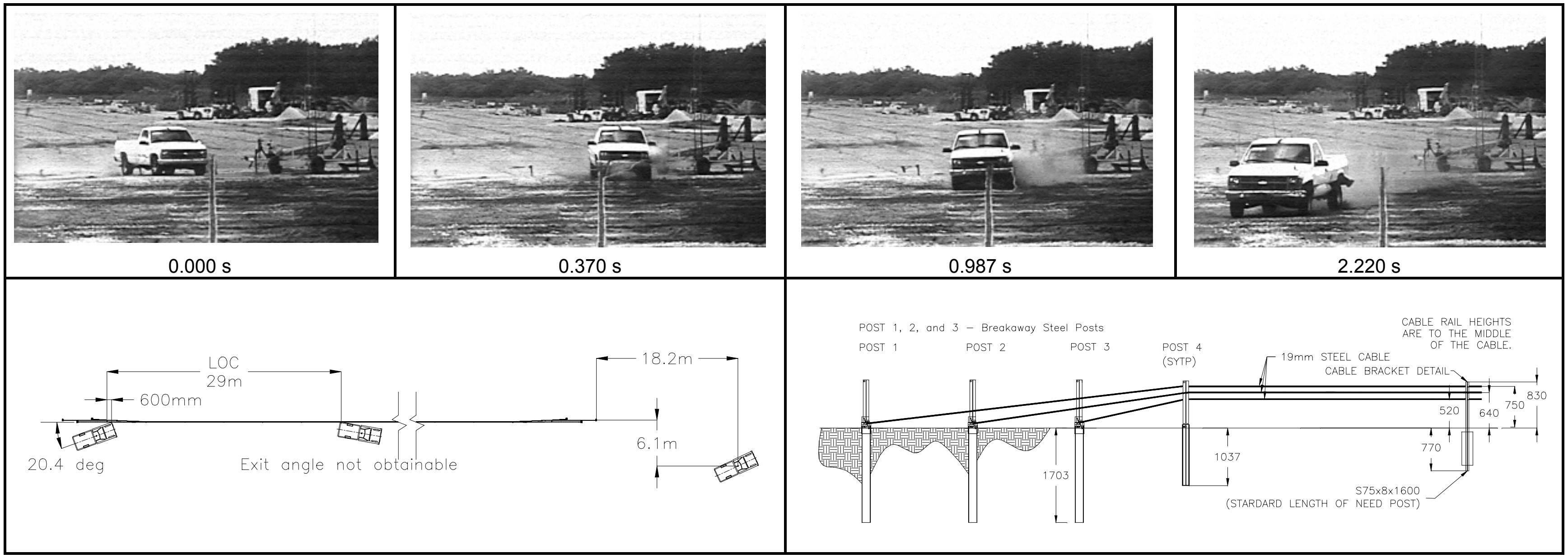


General Information	
Test Agency	Texas Transportation Institute
Test No.	220502-1
Date	10/05/01
Test Article	
Type	End Treatment
Name	New Terminal For Cable Guardrail
Installation Length (m)	106.4
Material or Key Elements	Three-Cable Guardrail System Anchored With New Breakaway Steel Posts
Soil Type and Condition	Standard Soil, Dry
Test Vehicle	
Type	Production
Designation	820C
Model	1998 Geo Metro
Mass (kg)	
Curb	808
Test Inertial	820
Dummy	76
Gross Static	896

Impact Conditions	
Speed (km/h)	100.3
Angle (deg)	15.2
Exit Conditions	
Speed (km/h)	N/A
Angle (deg)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	3.2
y-direction	2.8
THIV (km/h)	14.3
Ridedown Accelerations (g's)	
x-direction	-5.9
y-direction	2.8
PHD (g's)	6.1
ASI	0.52
Max. 0.050-s Average (g's)	
x-direction	-3.7
y-direction	3.2
z-direction	-3.2

Test Article Deflections (m)	
Dynamic	1.53
Permanent	1.31
Working Width	1.61
Vehicle Damage	
Exterior	
VDS	11FL2
CDC	11FLEW2
Maximum Exterior Vehicle Crush (mm)	230
Interior	
OCDI	LF0000000
Max. Occ. Compart. Deformation (mm)	N/A
Post-Impact Behavior (during 1.0 s after impact)	
Max. Yaw Angle (deg)	21.9
Max. Pitch Angle (deg)	4.9
Max. Roll Angle (deg)	-27.9

Summary of results for test 220502-1, *NCHRP Report 350* test 3-34.



General Information	
Test Agency	Texas Transportation Institute
Test No.	220502-2
Date	10/22/01
Test Article	
Type	End Treatment
Name	New Terminal For Cable Guardrail
Installation Length (m)	106.4
Material or Key Elements	Three-Cable Guardrail System Anchored With New Breakaway Steel Posts
Soil Type and Condition	Standard Soil, Dry
Test Vehicle	
Type	Production
Designation	2000P
Model	1998 Chevrolet 2500 Pickup Truck
Mass (kg)	
Curb	2159
Test Inertial	2030
Dummy	N/A
Gross Static	2030

Impact Conditions	
Speed (km/h)	101.7
Angle (deg)	20.4
Exit Conditions	
Speed (km/h)	N/A
Angle (deg)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	2.0
y-direction	3.4
THIV (km/h)	15.3
Ridedown Accelerations (g's)	
x-direction	-3.7
y-direction	-5.7
PHD (g's)	6.1
ASI	0.34
Max. 0.050-s Average (g's)	
x-direction	-1.9
y-direction	-2.9
z-direction	-1.4

Test Article Deflections (m)	
Dynamic	1.56
Permanent	1.56
Working Width	1.89
Vehicle Damage	
Exterior	
VDS	11FL2
CDC	11FLEW2
Maximum Exterior Vehicle Crush (mm)	230
Interior	
OCDI	LF0000000
Max. Occ. Compart. Deformation (mm)	N/A
Post-Impact Behavior (during 1.0 s after impact)	
Max. Yaw Angle (deg)	21.1
Max. Pitch Angle (deg)	-10.4
Max. Roll Angle (deg)	14.4

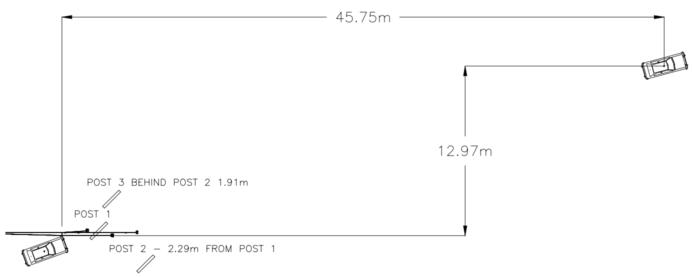
Summary of results for test 220502-2, *NCHRP Report 350* test 3-35.

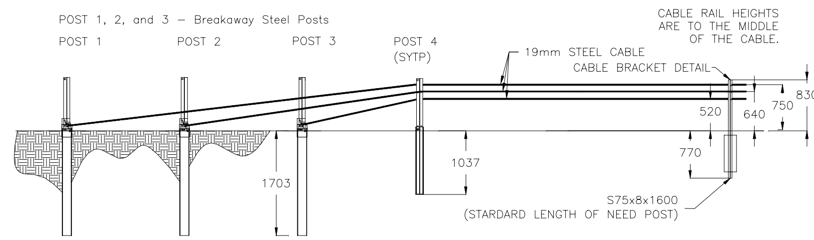
0.000 s

0.149 s

0.496 s

0.892 s





General Information	
Test Agency	Texas Transportation Institute
Test No.	220502-3
Date	10/25/01
Test Article	
Type	End Treatment
Name	New Terminal For Cable Guardrail
Installation Length (m)	106.4
Material or Key Elements	Three-Cable Guardrail System Anchored With New Breakaway Steel Posts
Soil Type and Condition	Standard Soil, Dry
Test Vehicle	
Type	Production
Designation	820C
Model	1997 Geo Metro
Mass (kg)	
Curb	844
Test Inertial	820
Dummy	76
Gross Static	896

Impact Conditions	
Speed (km/h)	102.1
Angle (deg)	20.0
Exit Conditions	
Speed (km/h)	74.5
Angle (deg)	20.5
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	7.2
y-direction	1.7
THIV (km/h)	26.8
Ridedown Accelerations (g's)	
x-direction	-5.5
y-direction	-2.9
PHD (g's)	5.6
ASI	0.67
Max. 0.050-s Average (g's)	
x-direction	-7.4
y-direction	3.0
z-direction	2.4

Test Article Deflections (m)	
Dynamic	2.29
Permanent	2.29
Working Width	1.82
Vehicle Damage	
Exterior	
VDS	11FL3
CDC	11FLEW3
Maximum Exterior Vehicle Crush (mm)	300
Interior	
OCDI	FS0002000
Max. Occ. Compart. Deformation (mm)	34
Post-Impact Behavior (during 1.0 s after impact)	
Max. Yaw Angle (deg)	-1.7
Max. Pitch Angle (deg)	-10.2
Max. Roll Angle (deg)	6.9

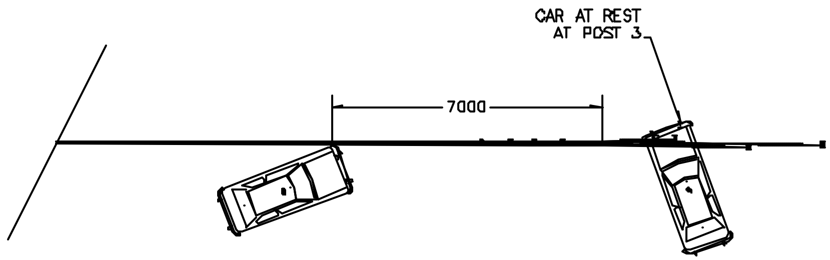
Summary of results for test 220502-3, *NCHRP Report 350* test 3-39.

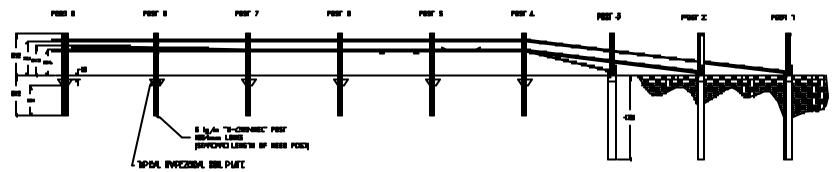
0.000 s

0.119 s

0.534 s

1.543 s





General Information

Test Agency	Texas Transportation Institute
Test No.	220502-7
Date	06/24/02

Test Article

Type	End Treatment
Name	New Terminal for Cable Guardrail
Installation Length (m)	106.0
Material or Key Elements	Three-Cable Guardrail System Anchored With New Break-Away Steel Posts

Soil Type and Condition .... Standard Soil, Dry

Test Vehicle

Type	Production
Designation	820C
Model	1997 Geo Metro
Mass (kg)	
Curb	780
Test Inertial	820
Dummy	N/A
Gross Static	820

Impact Conditions

Speed (km/h)	100.2
Angle (deg)	21.1

Exit Conditions

Speed (km/h)	N/A
Angle (deg)	N/A

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	6.7
y-direction	4.6
THIV (km/h)	27.7
Ridedown Accelerations (g's)	
x-direction	-14.4
y-direction	9.9
PHD (g's)	14.4
ASI	0.80
Max. 0.050-s Average (g's)	
x-direction	-8.3
y-direction	6.0
z-direction	2.9

Test Article Deflections (m)

Dynamic	0.77
Permanent	0.15
Working Width	1.00

Vehicle Damage

Exterior	
VDS	11FL3
CDC	11FLEW3
Maximum Exterior Vehicle Crush (mm)	400
Interior	
OCDI	LF0002000
Max. Occ. Compart. Deformation (mm)	17

Post-Impact Behavior

(during 1.0 s after impact)

Max. Yaw Angle (deg)	-83.4
Max. Pitch Angle (deg)	18.0
Max. Roll Angle (deg)	17.5

Summary of results for test 220502-7, *NCHRP Report 350* test 3-39 (with 820C vehicle).