September 2, 1999

Refer to: HMHS-CC12F

Mr. Rodney A. Boyd
Trinity Industries, Inc.
Rollform Division
2525 Stemmons Freeway
Dallas, Texas 75207

Dear Mr. Boyd:

In his July 26 letter, Mr. James Albritton requested the Federal Highway Administration's (FHWA) acceptance of a hinged breakaway (HBA) steel post as an alternative to the breakaway wood posts currently used in the ET-2000 w-beam guardrail terminal. To support this request, Mr. Albritton also sent copies of a Texas Transportation Institute June 1999 test report entitled "Testing and Evaluation of the ET-2000 with Steel HBA Posts" and videotapes showing the crash tests that were conducted to verify acceptable performance of the modified design. On August 24, Mr. Richard Powers of my staff received additional information he had requested from Mr. Albritton, including copies of the Texas Transportation Institute August 1999 report entitled "NCHRP Report 350 Test 3-35 on the ET-2000 with 4 HBA Posts and 4 CRT Posts".

Two different HBA posts are used in the new design, both of which consist of two sections of W150x13 steel beams bolted together at splice plates welded to the flanges of each post section near the ground line. The first two posts consist of a 740-mm long top posts and 1780-mm long bottom posts. These post are connected to each other with a 76 mm x 76 mm x 6 mm steel ground strut and, with the addition of a steel cable, form the anchorage for the barrier system. The remaining HBA posts are similar to the first two, but the top posts are 665-mm long and the bottom posts are 1070-mm long. These and other design details are shown in Enclosure 1. The post spacing itself is unchanged from the current ET-2000 design. In an end-on hit, the leading 9.5 mm bolts in the splice plate shear and allow the post to pivot or rotate around the 19 mm bolts. In a side impact, the welded splice plate and 19 mm bolt transfer the lateral loading to the bottom post and provide some re-directive capability.

To show that the HBA posts were an acceptable substitute for the original wood post design, you ran four tests as reported above. Summaries of each test are shown in Enclosure 2.

We agree that the tests you ran satisfactorily demonstrate that the all-steel HBA post design is equal in performance to the breakaway wood post design of the ET-2000 and that the appropriate HBA post may be substituted for any or all of the eight breakaway wood posts currently used.

Sincerely yours,

(original signed by Dwight A. Horne)

Dwight A. Horne
Director, Office of Highway Safety Infrastructure

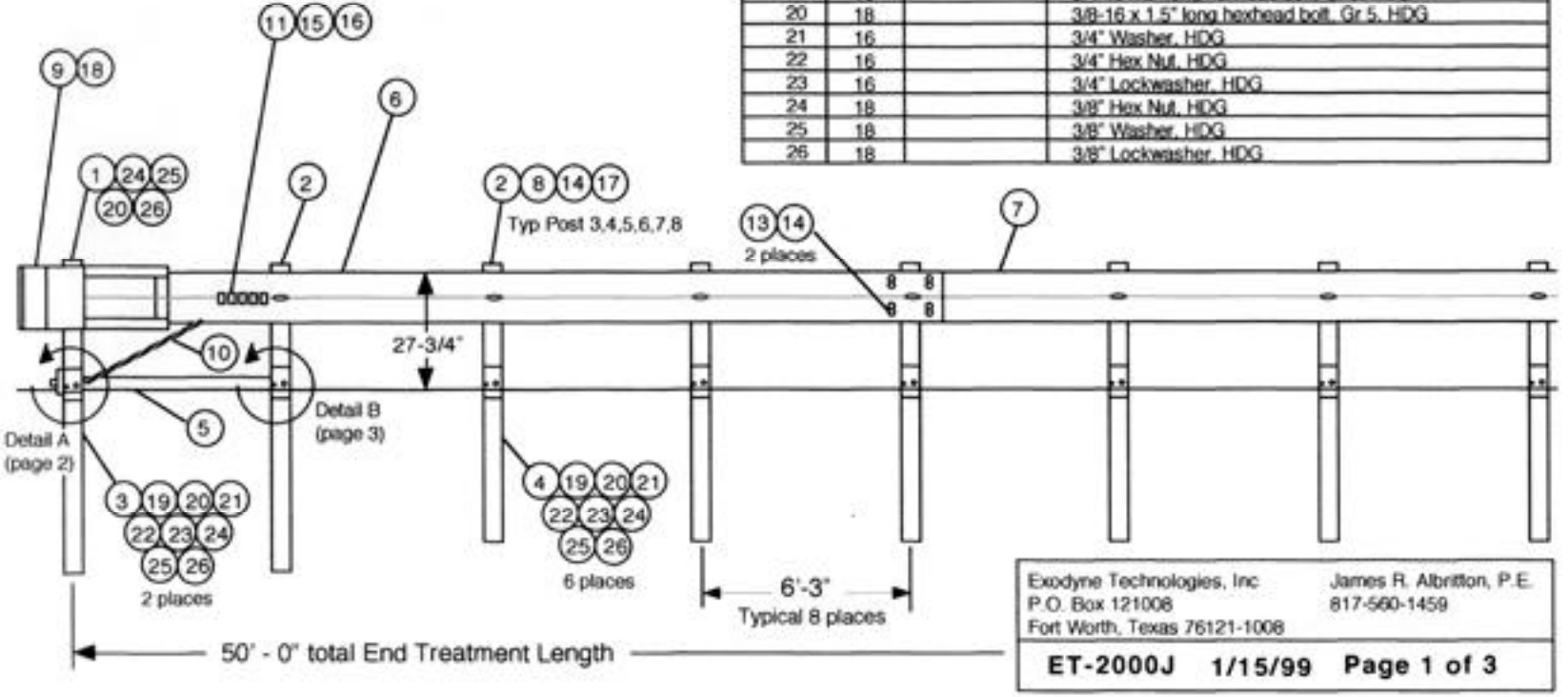
2 Enclosures

Notes:

1. There is no routed wood block at post #1 and post #2.
2. No rail to post attachment at post #2 and post #5.
3. A portion of item 12 may be below grade.
4. Torque on 3/4" bolts should be 250 ft-lbs.
5. Torque on 3/8" bolts should be 38 ft-lbs.

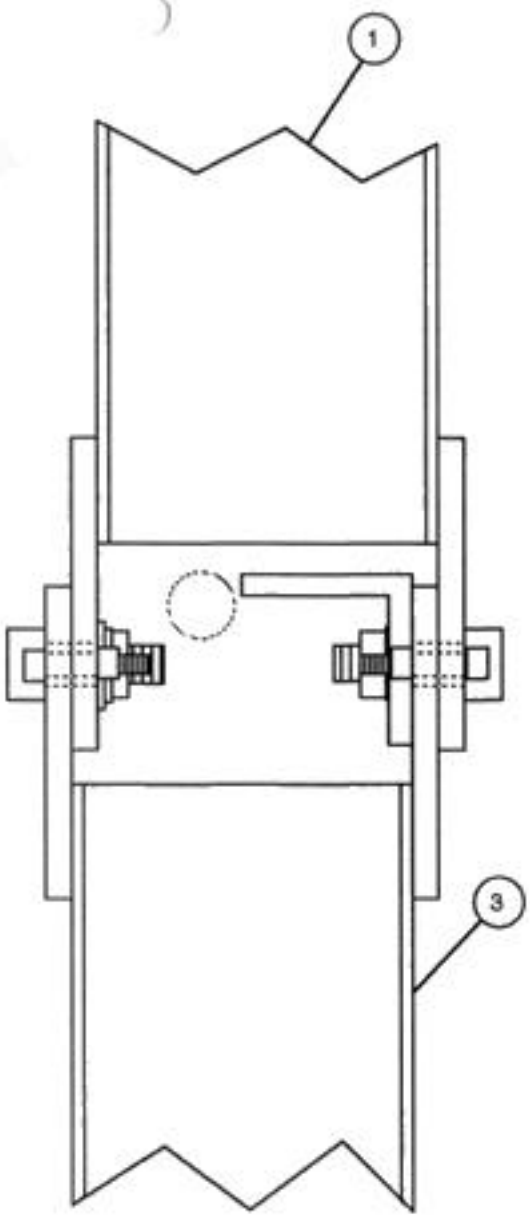
Parts List

Itx	Qty	Part Number	Description
1	1	JTop 1	Breakaway Post Top #1
2	7	JTop 2	Breakaway Post Top #2
3	2	JBottom 1	Breakaway Post Bottom #1
4	6	JBottom 2	Breakaway Post Bottom #2
5	1	JStrut2	Ground Strut
6	1	62G	#1 Deep Beam Guard Rail (12ga)
7	1	60G	#2 Deep Beam Guard Rail (12 ga)
8	6	4076B	Routed Wood Block
9	1	985A	Guardrail Extruder
10	1	3000G	Cable Assembly
11	1	704A	Cable Anchor Bracket
12	1	782G	Bearing Plate - 8" x 8" x 5/8"
13	16	3360G	5/8" x 1-1/4" HGR Splice Bolts
14	22	3340G	5/8" HGR Nut
15	2	3910G	1" Hex Nut
16	2	3900G	1" Washer
17	6	3500G	5/8" x 10" HGR Post Bolt
18	1	3177B	Object Marker (18" x 18") Decal
19	16		3/4-10 x 2" long hexhead bolt, Gr 5, HDG
20	18		3/8-16 x 1.5" long hexhead bolt, Gr 5, HDG
21	16		3/4" Washer, HDG
22	16		3/4" Hex Nut, HDG
23	16		3/4" Lockwasher, HDG
24	18		3/8" Hex Nut, HDG
25	18		3/8" Washer, HDG
26	18		3/8" Lockwasher, HDG



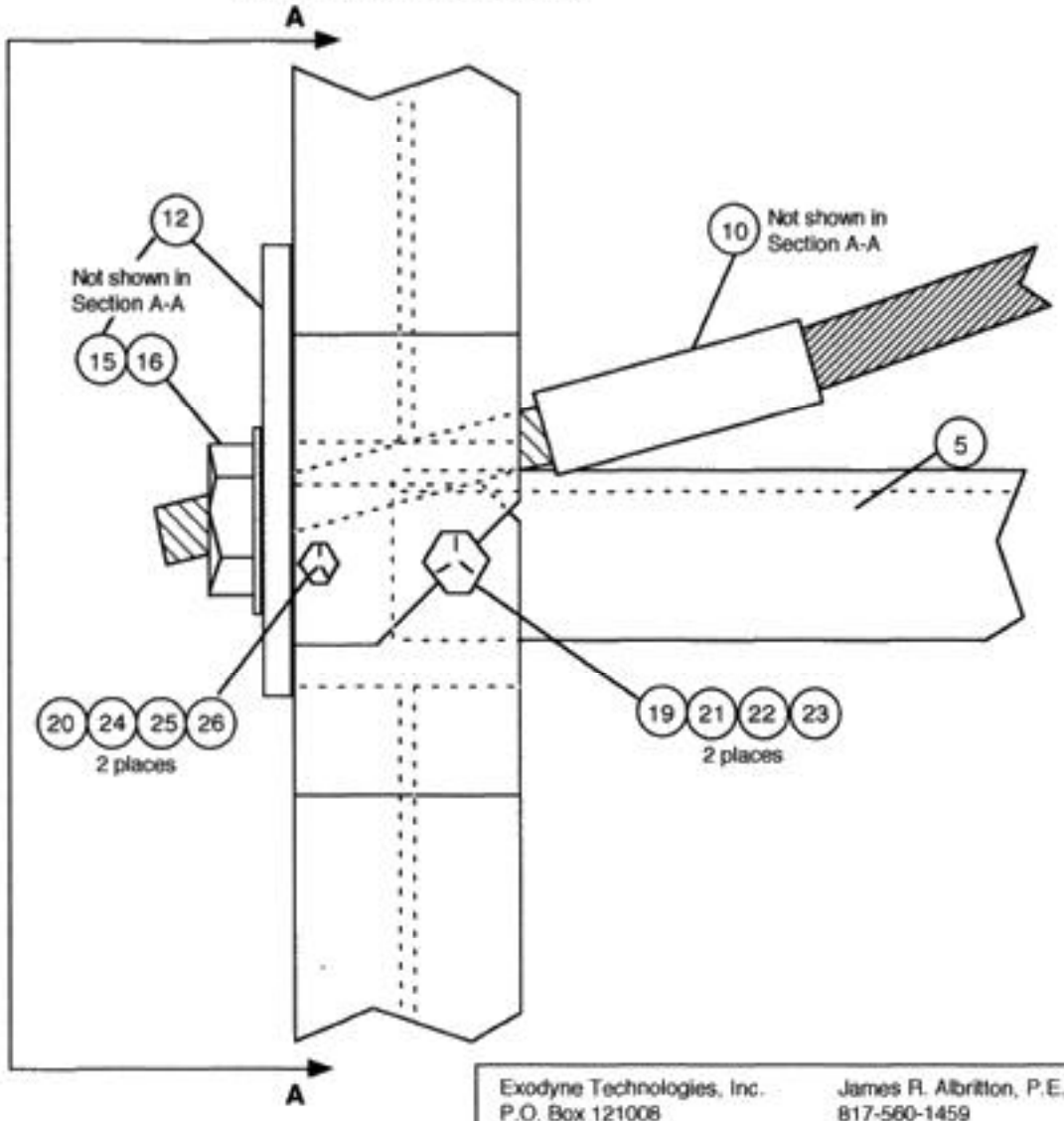
Exodyne Technologies, Inc
P.O. Box 121008
Fort Worth, Texas 76121-1008

James R. Albritton, P.E.
817-560-1459



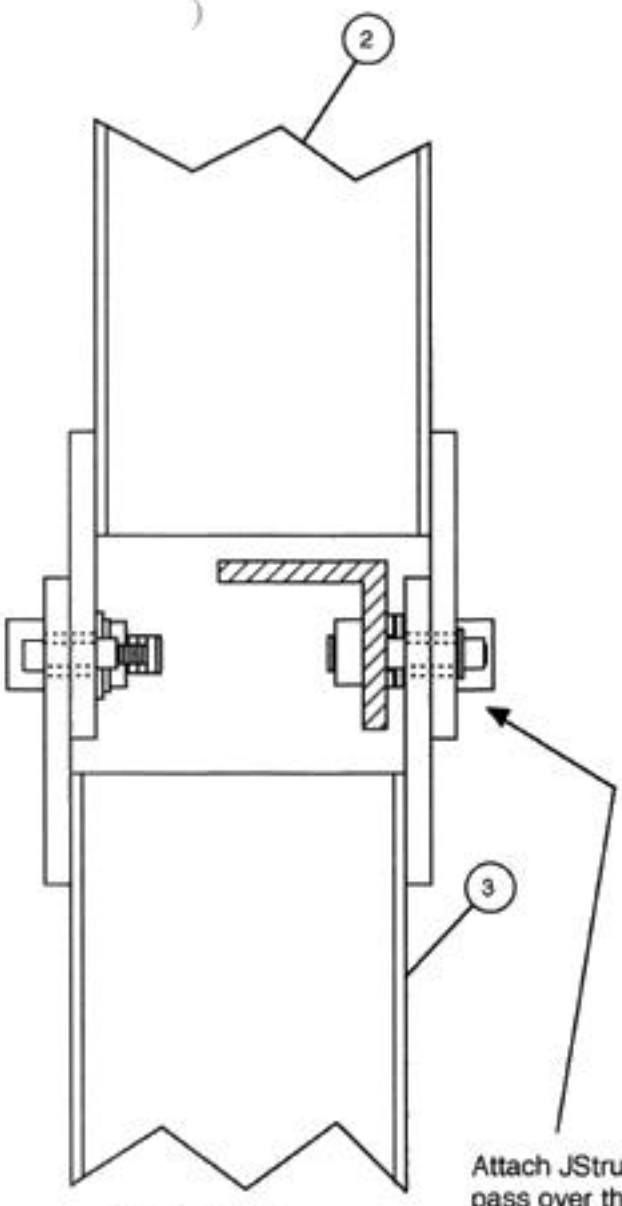
Section A-A

Detail A (From page 1)



Exodyne Technologies, Inc.
P.O. Box 121008
Fort Worth, Texas 76121

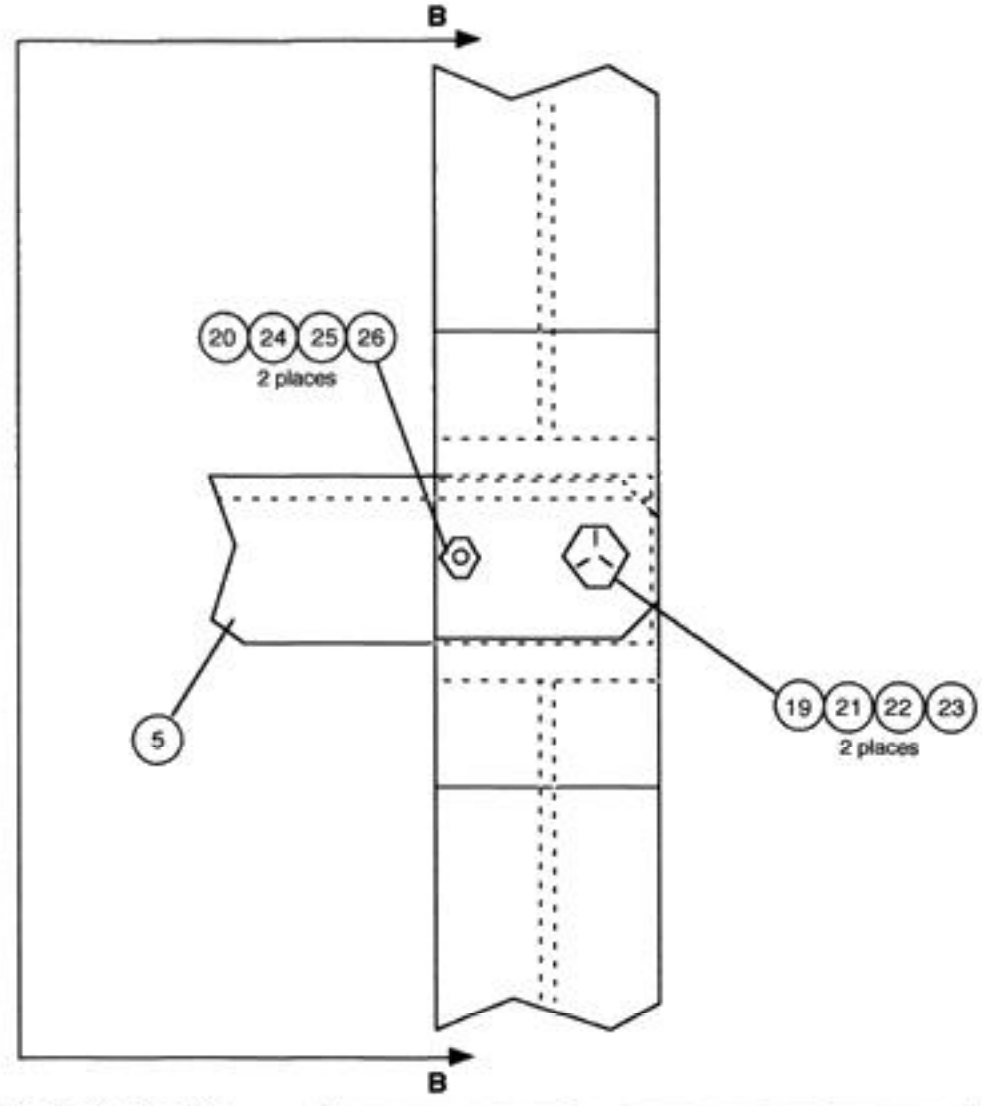
James R. Albritton, P.E.
817-560-1459



Section B-B

Attach JStrut2 to 3/4" bolt allowing it to pass over the head of the 3/8" bolt. Stack washers between JStrut2 and post flange to fill space.

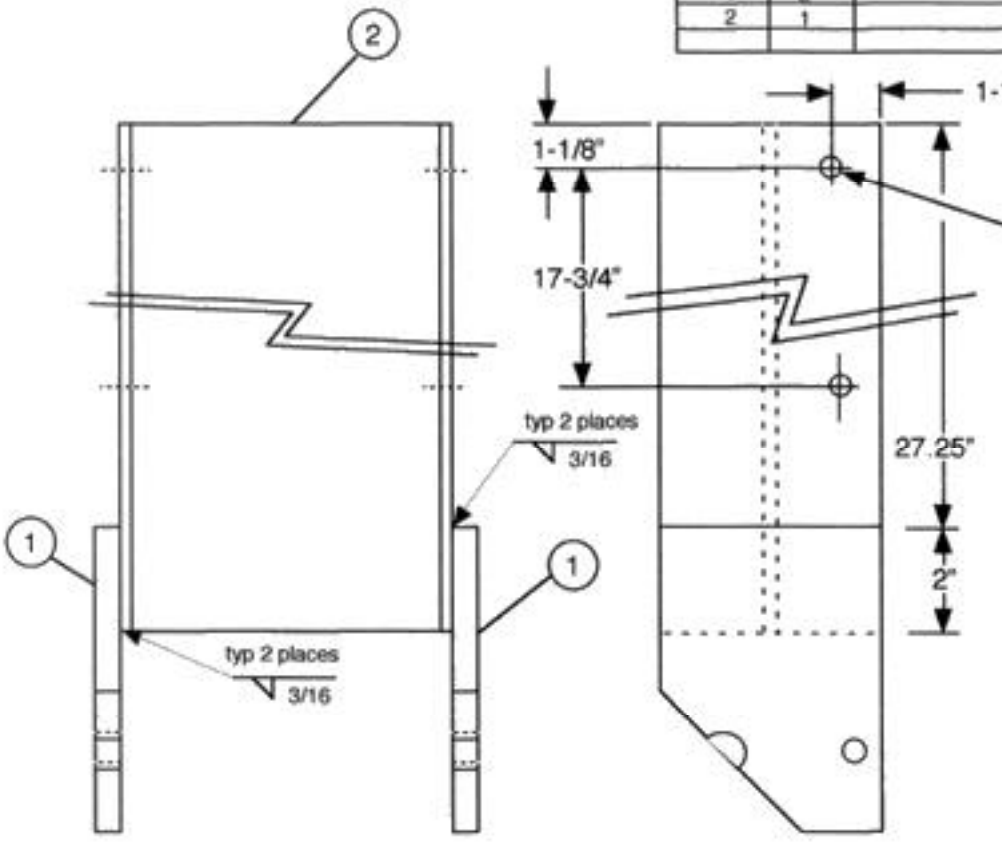
Detail B (From page 1)

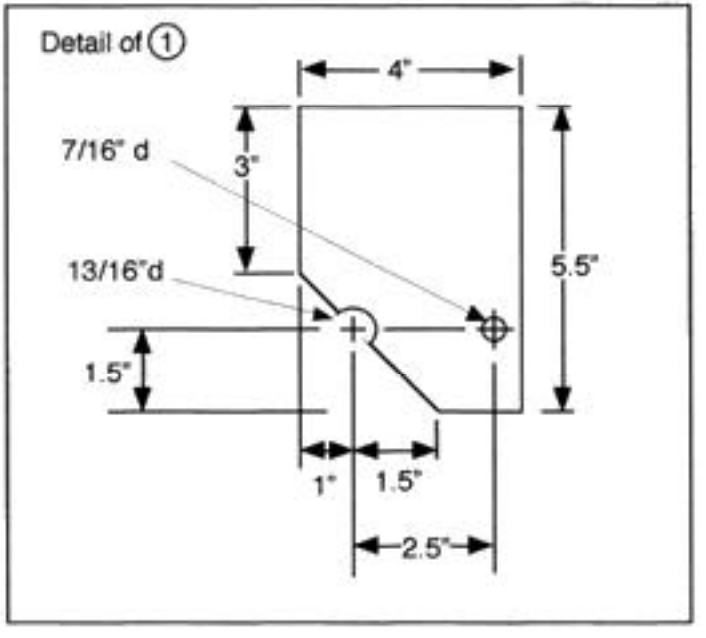


Exodyne Technologies, Inc.
P.O. Box 121008
Fort Worth, Texas 76121

James R. Albritton, P.E.
817-560-1459

Parts List			
Item	Qty	Part Number	Description
1	2		0.5" x 4" x 5.5" A36 HRS plate
2	1		W6x8.5 x 29.25" long A36 HRS





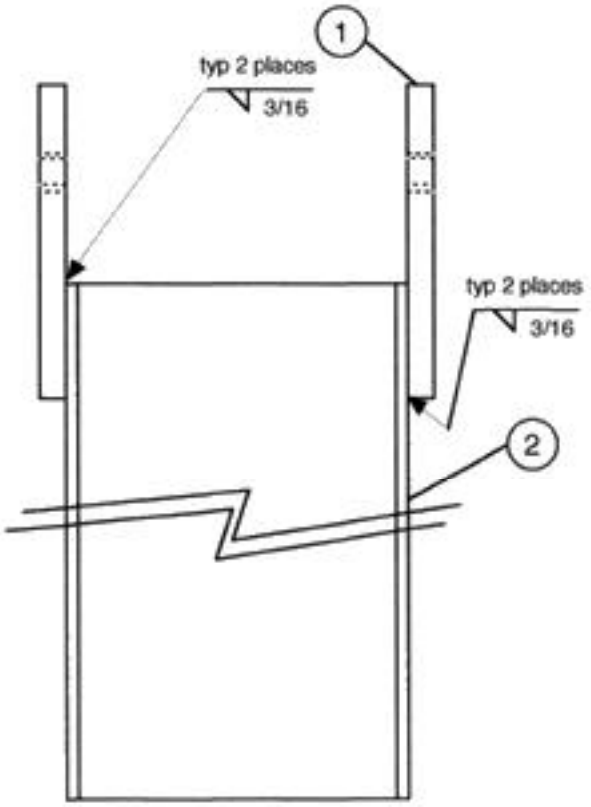
Notes:
1. Square and debur all edges
2. Galvanize after welding.
3. Diagonal cut should be made with saw after holes are drilled.

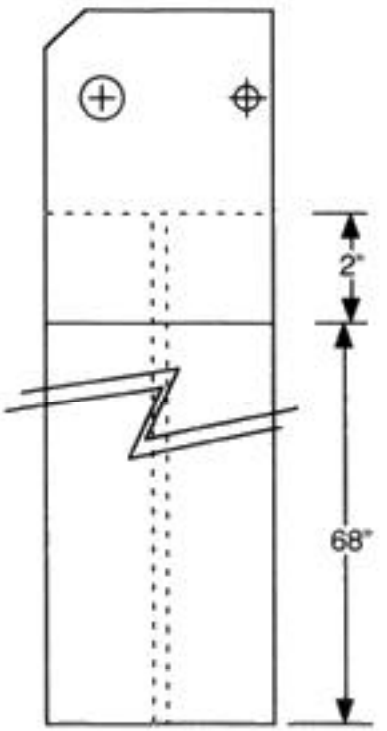
Exodyne Technologies, Inc.
P.O. Box 121008
Fort Worth, Texas 76121

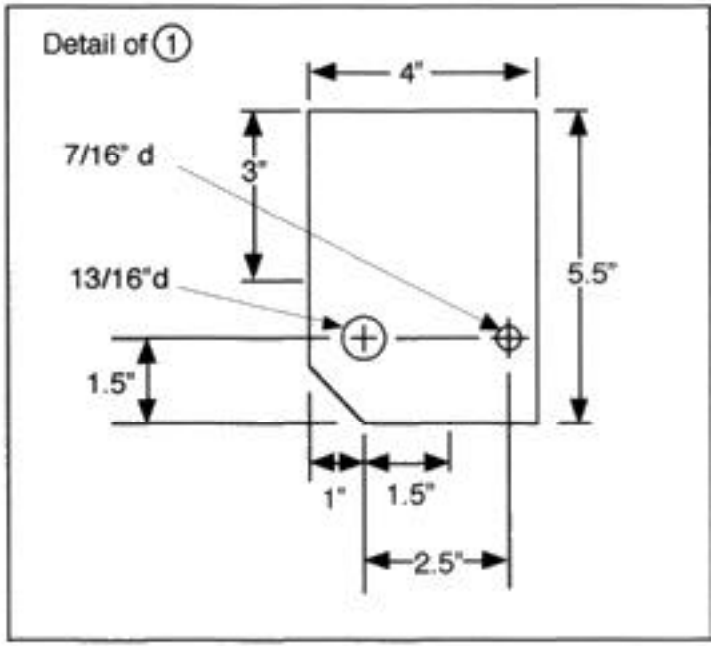
James R. Albritton, P.E.
817-560-1459

Part Name:	Breakaway Post Top #1
DRWG Number:	JTop 1
Date Released:	1/15/99

Parts List			
Item	Qty	Part Number	Description
1	2		0.5" x 4" x 5.5" A36 HRS plate
2	1		W6x8.5 x 70" long A36 HRS







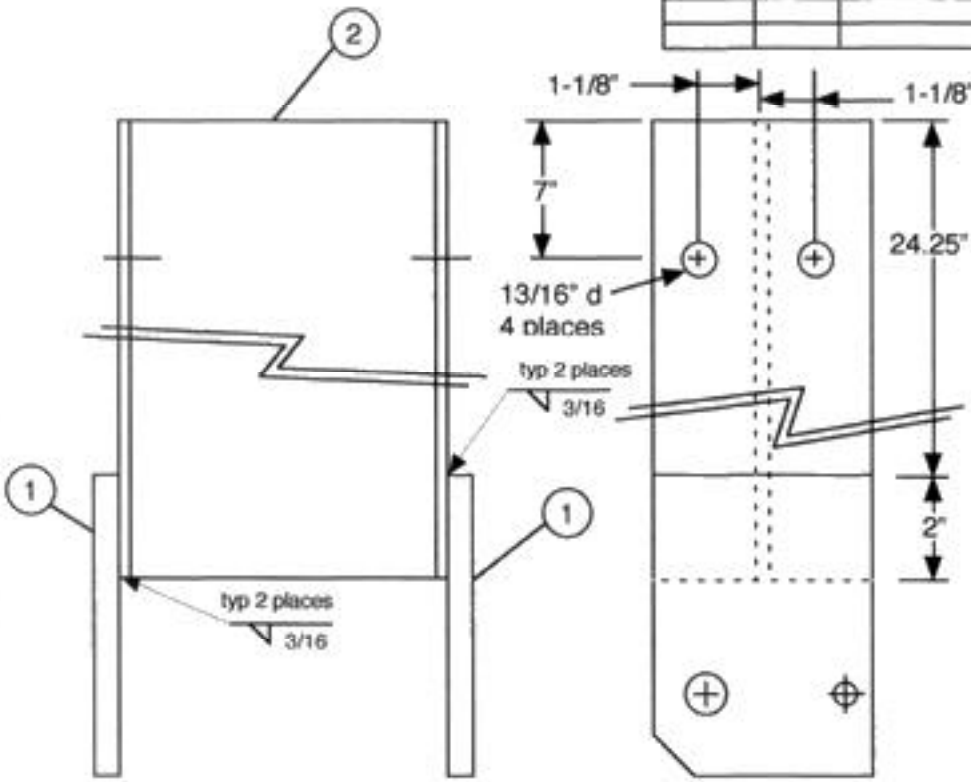
Notes:
1. Square and debur all edges
2. Galvanize after welding.

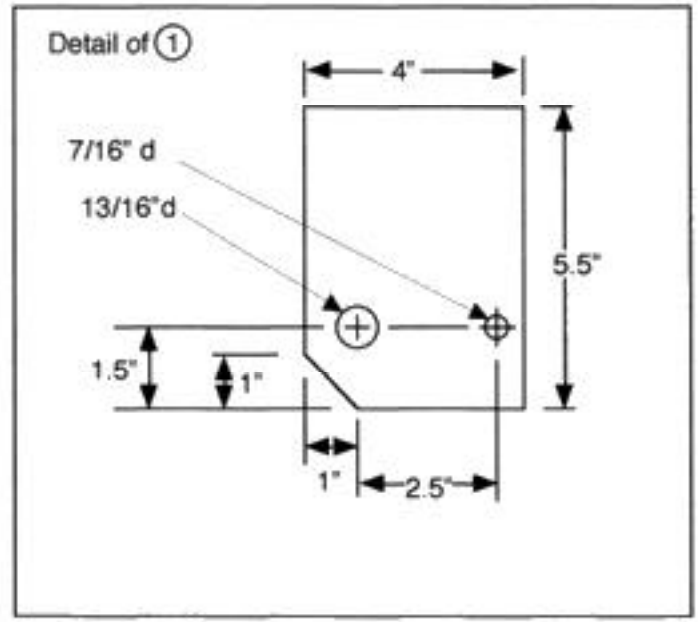
Exodyne Technologies, Inc.
P.O. Box 121008
Fort Worth, Texas 76121

James R. Albritton, P.E.
817-560-1459

Part Name:	Breakaway Post Bottom #1
DRWG Number:	JBottom 1
Date Released:	1/15/99

Parts List			
Item	Qty	Number	Description
1	2		0.5" x 4" x 5.5" A36 HRS plate
2	1		W6x8.5 x 26.25" long A36 HRS





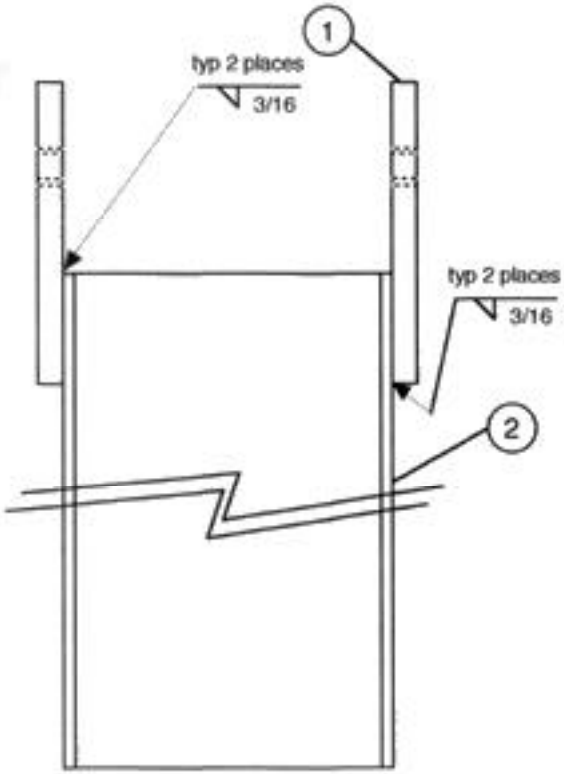
Notes:
1. Square and debur all edges
2. Galvanize after welding.

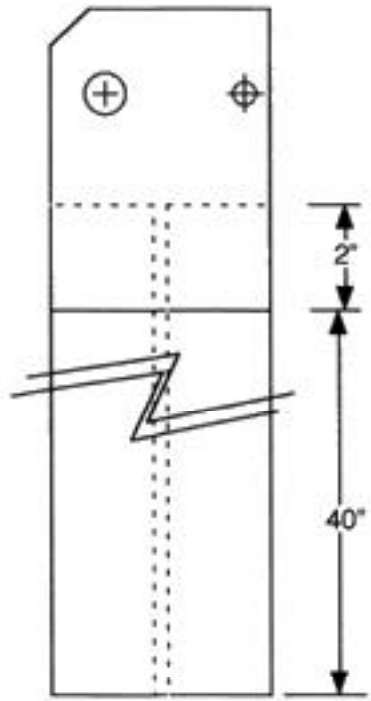
Exodyne Technologies, Inc.
P.O. Box 121008
Fort Worth, Texas 76121

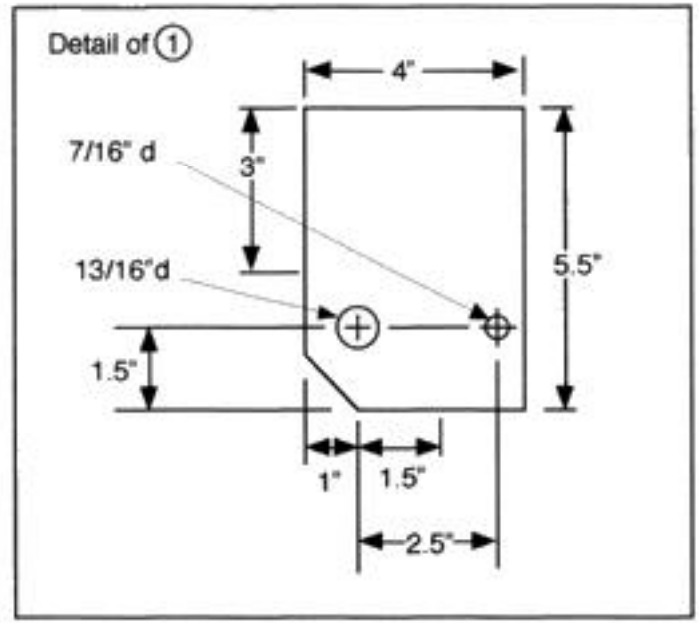
James R. Albritton, P.E.
817-560-1459

Part Name:	Breakaway Post Top #2
DRWG Number:	JTop 2
Date Released:	1/15/99

Parts List			
Item	Qty	t Number	Description
1	2		0.5" x 4" x 5.5" A36 HRS plate
2	1		W6x8.5 x 42" long A36 HRS





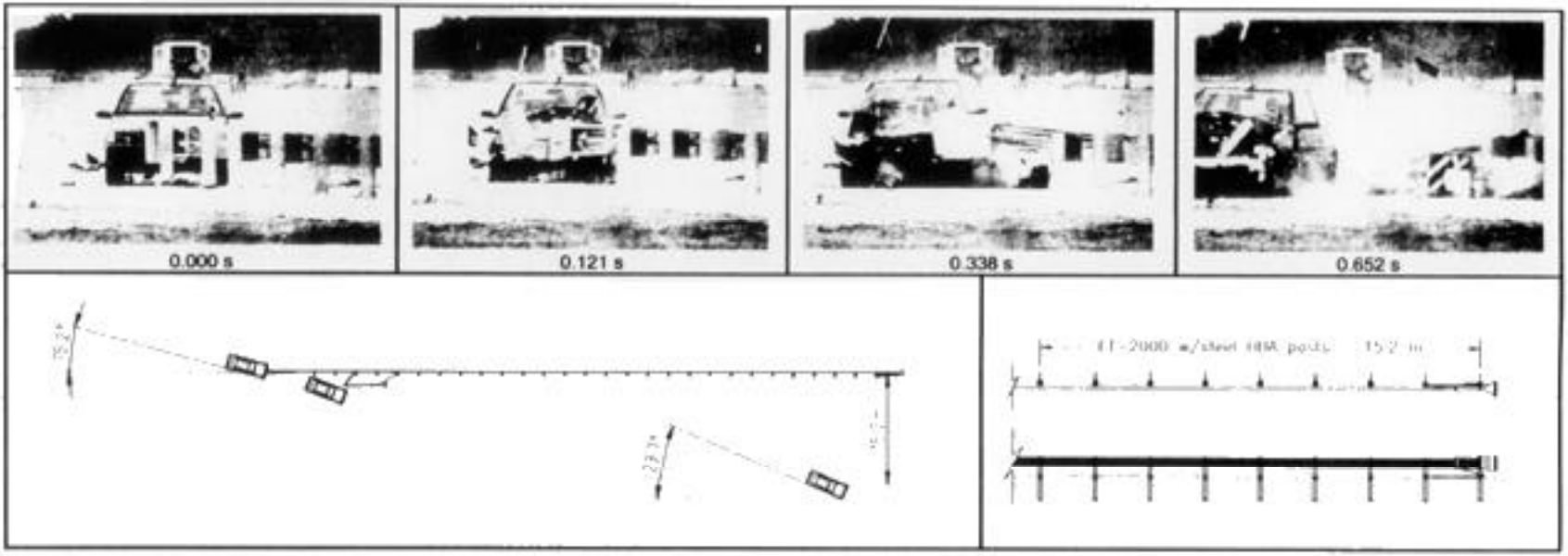


Notes:
1. Square and debur all edges
2. Galvanize after welding.

Exodyne Technologies, Inc.
P.O. Box 121008
Fort Worth, Texas 76121

James R. Albritton, P.E.
817-560-1459

Part Name:	Breakaway Post Bottom #2
DRWG Number:	JBottom 2
Date Released:	1/15/99



General Information
- Test Agency: Texas Transportation Institute
- Test No.: 400001-XTI2
- Date: 02/09/99

Test Article
- Type: Terminal
- Name: ET-2000 with Steel HBA Posts
- Installation Length (m): 57.2
- Material or Key Elements: Guardrail Extruder Terminal on Blocked-out Steel Hinged Breakaway Posts

Soil Type and Condition: Standard Soil, Dry

Test Vehicle
- Type: Production
- Designation: 820C
- Model: 1993 Geo Metro
- Mass (kg)
  - Curb: 769
  - Test Inertial: 820
  - Dummy: 76
  - Gross Static: 896

Impact Conditions
- Speed (km/h): 101.1
- Angle (deg): 15.2

Exit Conditions
- Speed (km/h): 58.9
- Angle (deg): 23.7 behind

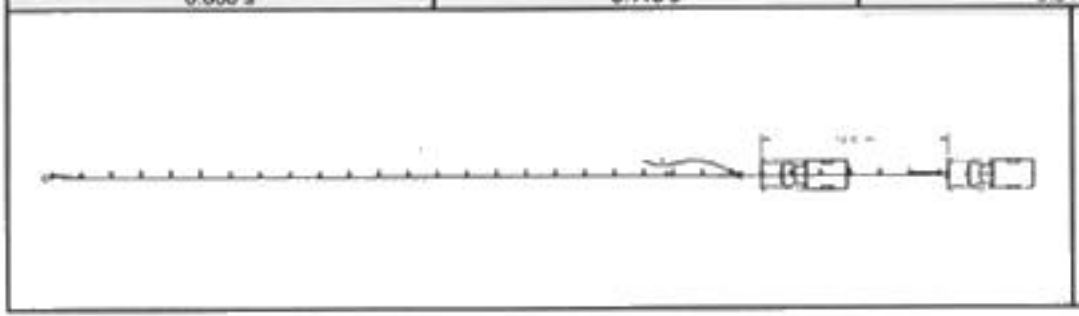
Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction: 8.2
  - y-direction: 1.6
- THIV (km/h): 29.2
- Ridedown Accelerations (g's)
  - x-direction: 5.6
  - y-direction: 4.3
- PHD (g's): 15.1
- ASI: 0.96
- Max. 0.050-s Average (g's)
  - x-direction: -11.6
  - y-direction: 2.4
  - z-direction: -2.2

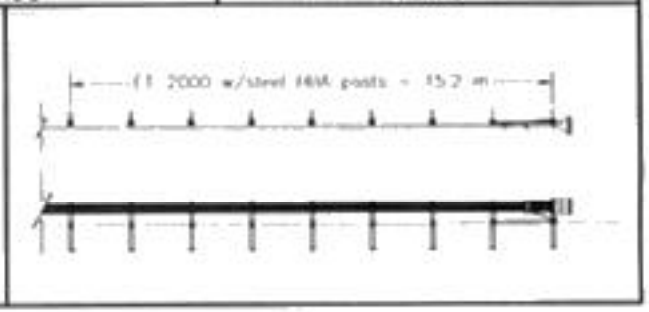
Test Article Deflections (m)
- Dynamic: 7.10
- Permanent: 2.63

Vehicle Damage
- Exterior
  - VDS: 12FC5
  - CDC: 12FCEW2
- Maximum Exterior
  - Vehicle Crush (mm): 360
- Interior
  - OCDI: FS0011000
- Max. Occ. Compart. Deformation (mm): 42

Post-Impact Behavior (during 1.0 s after impact)
- Max. Yaw Angle (deg): 12
- Max. Pitch Angle (deg): -12
- Max. Roll Angle (deg): -4

Figure 25. Summary of results for test 400001-XTI2, *NCHRP Report 350* test 3-32.





General Information

Test Agency	Texas Transportation Institute
Test No.	400001-XTI3
Date	05/21/99

Test Article

Type	Terminal
Name	ET-2000 with Steel HBA Posts
Installation Length (m)	57.2
Material or Key Elements	Guardrail Extruder Terminal on Blocked-out Steel Hinged Breakaway Posts
Soil Type and Condition	Standard Soil, Dry

Test Vehicle

Type	Production
Designation	2000P
Model	1994 Chevrolet 2500 pickup truck
Mass (kg)	
Curb	2169
Test Inertial	2000
Dummy	No dummy
Gross Static	2000

Impact Conditions

Speed (km/h)	98.9
Angle (deg)	0.9

Exit Conditions

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

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	6.1
y-direction	1.3
THIV (km/h)	21.9
Ridedown Accelerations (g's)	
x-direction	-5.5
y-direction	-3.1
PHD (g's)	5.7
ASI	0.57
Max. 0.050-s Average (g's)	
x-direction	-6.6
y-direction	-1.7
z-direction	1.9

Test Article Deflections (m)

Dynamic	7.50
Permanent	7.50

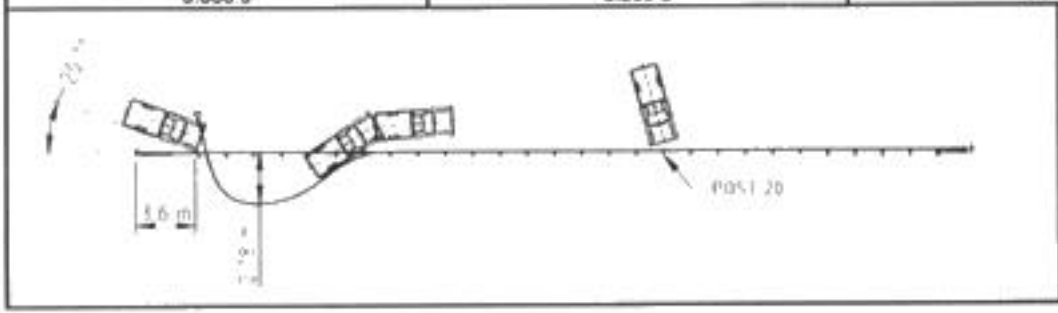
Vehicle Damage

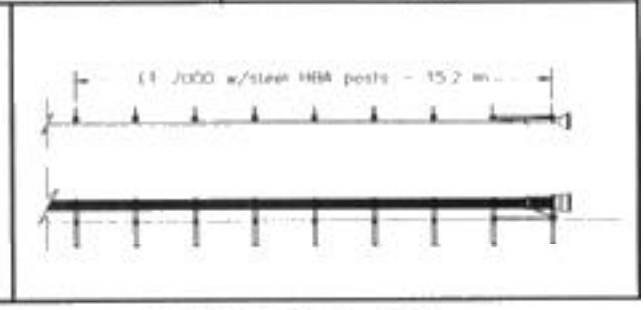
Exterior	
VDS	12FC3
CDC	12FCEN1
Maximum Exterior Vehicle Crush (mm)	440
Interior	
OCDI	FS0000000
Max. Occ. Compart. Deformation (mm)	nil

Post-Impact Behavior (during 1.0 s after impact)

Max. Yaw Angle (deg)	-3
Max. Pitch Angle (deg)	-6
Max. Roll Angle (deg)	4

Figure 32. Summary of results for test 400001-XTI3, *NCHRP Report 350* test 3-31.





General Information
- Test Agency: Texas Transportation Institute
- Test No.: 400001-XTI1
- Date: 01/05/99

Test Article
- Type: Terminal
- Name: ET-2000 with Steel HBA Posts
- Installation Length (m): 57.2
- Material or Key Elements: Guardrail Extruder Terminal on Blocked-out Steel Hinged Breakaway Posts

Soil Type and Condition: Standard Soil, Dry

Test Vehicle
- Type: Production
- Designation: 2000P
- Model: 1993 Chevrolet 2500 pickup truck
- Mass (kg)
  - Curb: 1858
  - Test Inertial: 2000
  - Dummy: No Dummy
  - Gross Static: 2000

Impact Conditions
- Speed (km/h): 99.9
- Angle (deg): 20.1

Exit Conditions
- Speed (km/h): 58.1
- Angle (deg): ~5

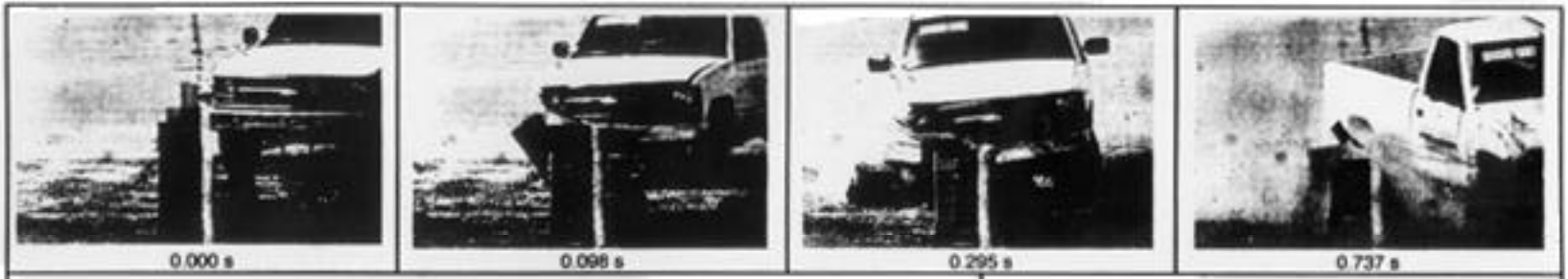
Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction: 5.2
  - y-direction: 3.9
- THIV (km/h): 15.4
- Ridedown Accelerations (g's)
  - x-direction: -8.8
  - y-direction: -8.8
- PHD (g's): 19.5
- ASI: 0.49
- Max. 0.050-s Average (g's)
  - x-direction: -4.3
  - y-direction: -3.6
  - z-direction: 2.7

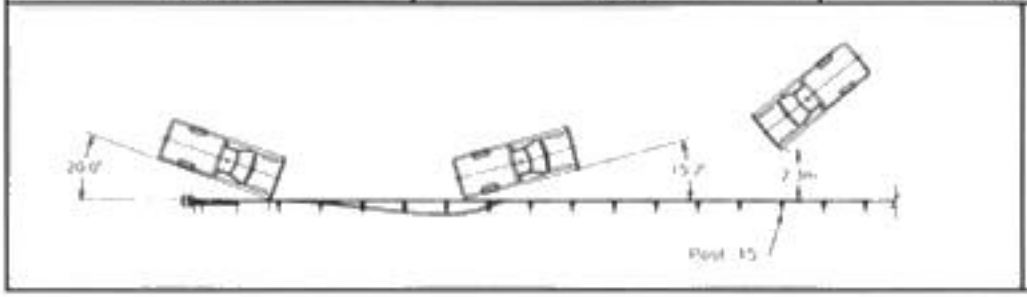
Test Article Deflections (m)
- Dynamic-before breakaway: 1.10
- Dynamic-after breakaway: 2.18

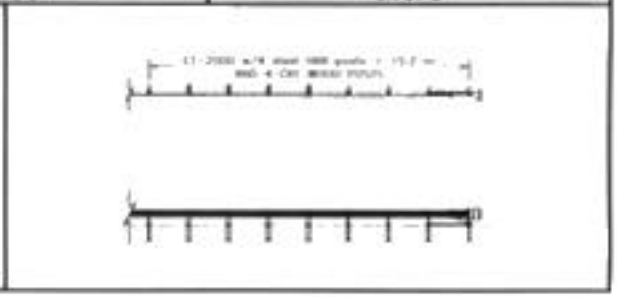
Vehicle Damage
- Exterior
  - VDS: 1RFQ4
  - CDC: 1FREK3 &1RFEW3
- Maximum Exterior
  - Vehicle Crush (mm): 330
- Interior
  - OCDI: RF0001000002
- Max. Occ. Compart. Deformation (mm): 150

Post-Impact Behavior (during 1.0 s after impact)
- Max. Yaw Angle (deg): -39
- Max. Pitch Angle (deg): -7
- Max. Roll Angle (deg): -10

Figure 16. Summary of results for test 400001-XTI1, *NCHRP Report 350* test 3-35.







General Information
- Test Agency ..... Texas Transportation Institute
- Test No. 400001-XTI4
- Date 07/16/99

Test Article
- Type ..... Terminal
- Name ..... ET-2000 with 4 HBA and 4 CRT Posts
- Installation Length (m) 57.2
- Material or Key Elements ... Guardrail Extruder Terminal on 4 Blocked-out Steel HBA & 4 CRT Posts

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

Test Vehicle
- Type ..... Production
- Designation 2000P
- Model ..... 1994 Chevrolet 2500 pickup truck
- Mass (kg)
  - Curb 2107
  - Test Inertial 2000
  - Dummy ..... No Dummy
  - Gross Static 2000

Impact Conditions
- Speed (km/h) 98.3
- Angle (deg) 20.0

Exit Conditions
- Speed (km/h) 46.0
- Angle (deg) 15.2

Occupant Risk Values
- Impact Velocity (m/s)
  - x-direction 5.8
  - y-direction 4.3
- THIV (km/h) 20.2
- Ridedown Accelerations (g's)
  - x-direction ..... -7.8
  - y-direction ..... -9.4
- PHD (g's) 11.3
- ASI 0.59
- Max. 0.050-s Average (g's)
  - x-direction ..... -4.2
  - y-direction ..... -4.2
  - z-direction 5.4

Test Article Deflections (m)
- Dynamic 0.978
- Permanent 0.310

Vehicle Damage
- Exterior
  - VDS 01RFQ4
  - CDC 01FREW3
- Maximum Exterior Vehicle Crush (mm) 300
- Interior
  - OCDI FS0005000
- Max. Occ. Compart. Deformation (mm) 84

Post-Impact Behavior (during 1.0 s after impact)
- Max. Yaw Angle (deg) ..... -35
- Max. Pitch Angle (deg) ..... -6
- Max. Roll Angle (deg) ..... -12

Figure 15. Summary of Results for test 400001-XTI4, *NCHRP Report 350* test 3-35.