



U.S. Department
of Transportation
**Federal Highway
Administration**

1200 New Jersey Avenue, SE.
Washington, DC 20590

February 13, 2009

In Reply Refer To: HSSD/CC-47D

Mr. Barry D. Stephens, P.E.
Senior Vice President of Engineering
Energy Absorption Systems, Inc.
3617 Cincinnati Avenue
Rocklin, CA 95765

Dear Mr. Stephens:

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

Name of system: Mod. TRITON Concrete End Treatment ACZ-350™ System
Type of system: Non-redirecting barrier terminal
Test Level: NCHRP Report 350 TL-3
Testing conducted by: E-TECH Testing Services
Date of request: December 17, 2008

You requested that we find this system 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 systems should meet the guidelines contained in the NCHRP Report 350. The FHWA Memorandum "Identifying Acceptable Highway Safety Features" of July 25, 1997, provides further guidance on crash testing requirements of longitudinal barriers.

Description

The ACZ-350™ System is designed to perform as a narrow, non-redirecting crash cushion to shield the blunt ends of both permanent and variable length portable concrete median barrier (P/CMB), as well as crashworthy steel median barrier systems such as the Vulcan Barrier.

The ACZ-350™ System consists of a sheet metal nose, four water-filled plastic shell segments, and a steel transition pinned together to act as an end treatment. The nose is constructed of light gauge steel and connects directly to the front-most water filled segment. Each of the four water filled segments is equipped with an external, top-mounted steel stiffener which is rigidly fixed to each respective segment. The front two water filled segments do not contain an internal steel frame or external, side-mounted laminated steel straps. In contrast, the next (or last) two water

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filled Triton segments are equipped with an internal steel frame as well as external side-mounted steel laminated straps. A heavy duty non-crushable steel transition completes the system by connecting the last water filled segment to the blunt end of the downstream barrier, be it P/CMB or Vulcan barrier. The total length of the ACZ-350TM System is 9.6 meters (31'-7"). In bi-directional traffic applications, there are no rigid exposed vehicle snag points for traffic traveling from the reverse direction.

Crash Testing

You requested acceptance of the ACZ-350TM System based on the successful results of three NCHRP Report 350 crash tests. The first was Test 3-40 in which an 820C compact car impacted the unit head-on, and with the vehicle offset at w/4. The second test was Test 3-41 in which a 2000P pickup truck impacted the unit head-on. The third test was a modification of Test 3-44 in which a 2000P vehicle impacts the side of the system at 20 degrees with the centerline of the vehicle aligned with the centerline of the rigid hazard. The NCHRP Report 350 states that the intent of Test 3-44 is "...to evaluate the ability of the cushion to safely stop a large passenger car prior to a life-threatening impact with the corner of the hazard object being shielded." Aligning the centerline of the impacting vehicle at the center of the shielded concrete barrier is clearly the critical impact point for the ACZ-350 design and the impact conditions are essentially the same as Test 3-38 for redirecting crash cushions. Report 350 acknowledges that test 3-38 "would be difficult to pass for a nonredirective crash cushion", and thus does not require that the nominal limiting occupant impact velocities and ridedown accelerations be achieved. However, we recognize your newly designed ACZ-350TM System is a nonredirective crash cushion that meets the occupant impact velocities and ridedown accelerations with reported values of 10.5 m/s and 18.4 g's while the impacting vehicle showed no evidence of penetration, climbing or vaulting.

We agree with your conclusions that Tests 3-42 and 3-43 do not require retesting. There has been no significant change in system shape, system height or component weights between the original TRITON CET and the ACZ-350. Individual system sections near the front of the system are designed to articulate in the same fashion as the TRITON Concrete End Treatment. This articulation will allow the errant vehicle to pass through the system as expected for a gating system. Based on these design principals we believe the new ACZ-350TM system will behave with similar results as the TRITON Concrete End Treatment when tested to 3-42 and 3-43 criteria.

Findings

Based upon the results of the reported Tests 3-40, 3-41, and 3-44, and the discussions above, the FHWA concludes the ACZ-350TM System is acceptable for use on the NHS to act as a narrow, non-redirecting gating crash cushion for permanent and portable concrete median barrier of varying individual lengths as well as steel barrier such as Vulcan. It is acceptable for use on the NHS under the range of conditions tested, when such use is acceptable to a highway agency. The cushion should be used in locations where side impacts are unlikely, penetration behind the barrier is acceptable for angled nose impacts, and where the use of a redirective crash cushion is not feasible for reasons other than cost or convenience.

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

- This acceptance is limited to the crashworthiness characteristics of the systems 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 system 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 system 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-47D 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 ACZ-350TM System is a patented product and considered proprietary. If proprietary systems 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 system for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate system, 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.

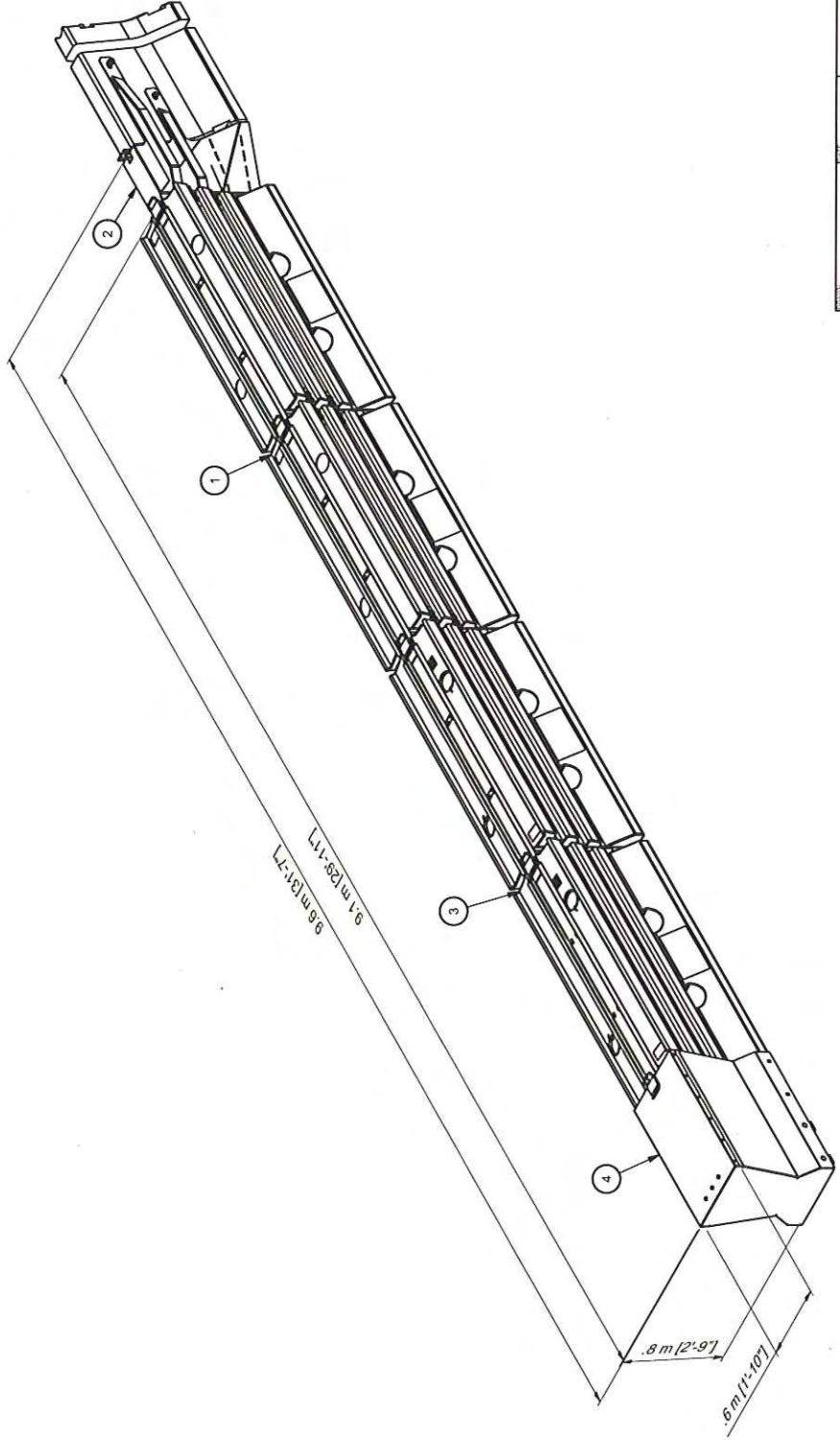
Sincerely yours,



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

Enclosures

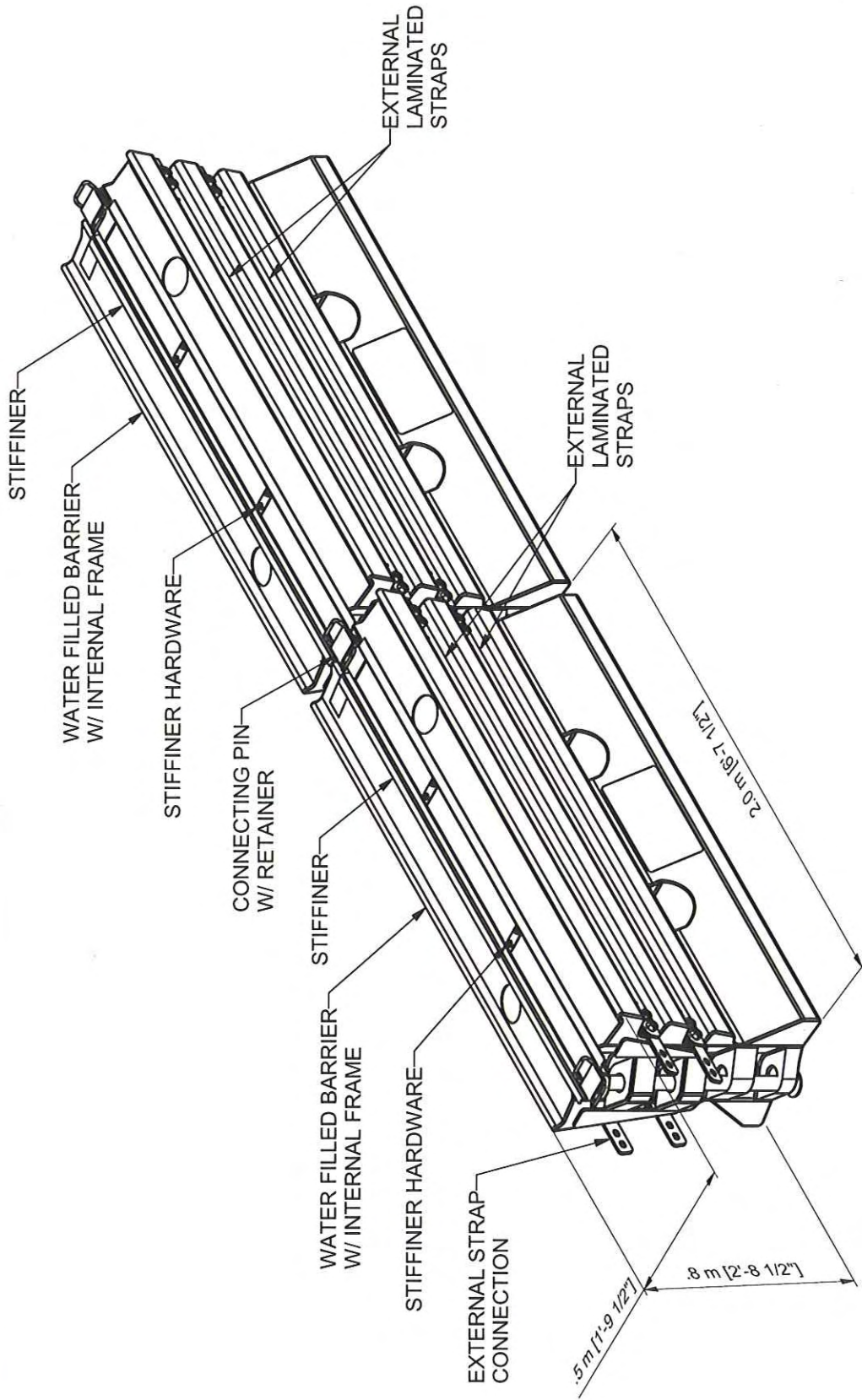
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ITEM	STOCK NO.	DESCRIPTION	QTY.
1		ACZ-350 SECTION 2	1
2		ACZ-350 TRANSITION ASSY	1
3		ACZ-350 SECTION 1	1
4		ACZ-350 NOSE ASSY	1



DATE	11/12/2008	ENERGY ABSORPTION SYSTEMS, INC.
DESIGNED BY	BAIVON COX	ENGINEERING AND RESEARCH DEPARTMENT
DRAWN BY	BAIVON COX	
CHECKED BY		
APPROVED BY		
SCALE		
UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN INCHES DIMENSIONS ARE SHOWN AS DECIMAL UNLESS OTHERWISE SPECIFIED		
DRAWING		SHEET
		1 of 1

ACZ-350 TL-3 CRASH CUSHION

Figure 1






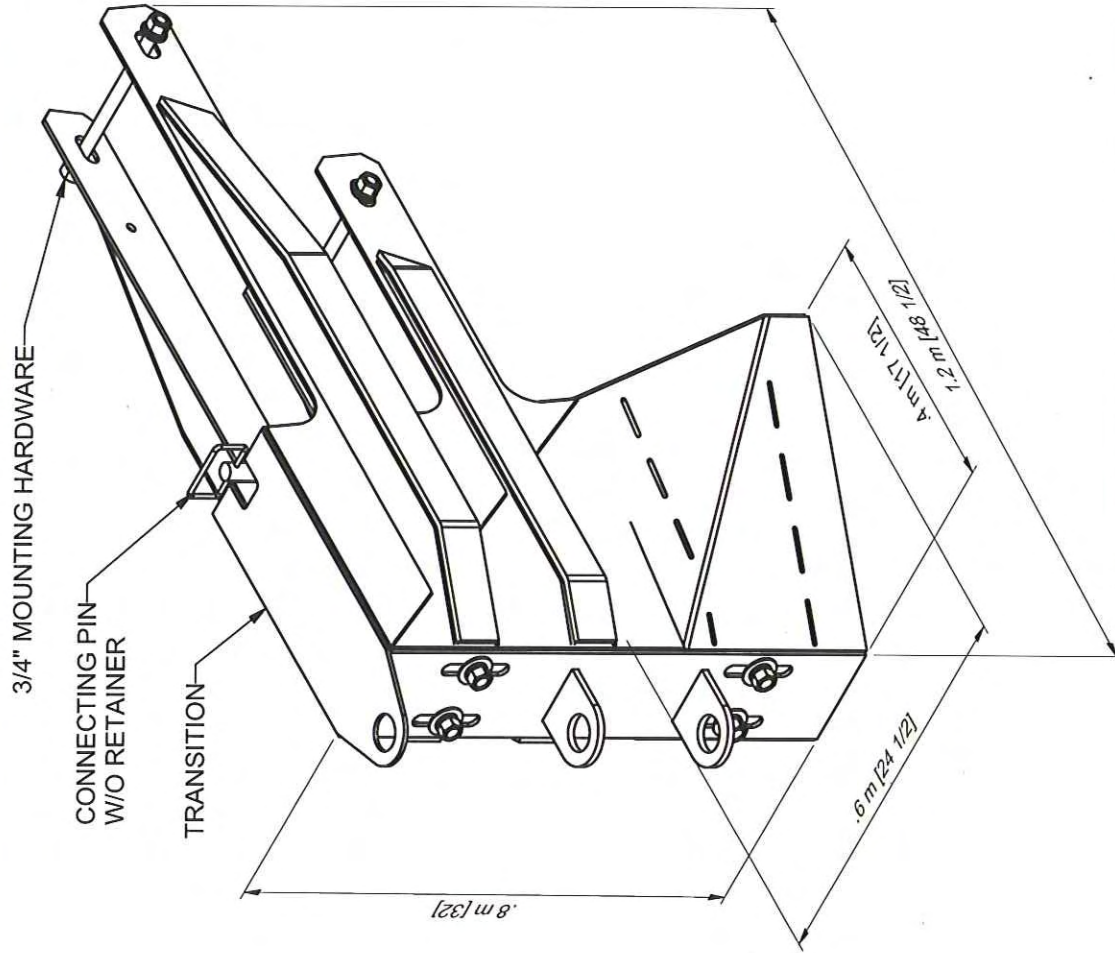
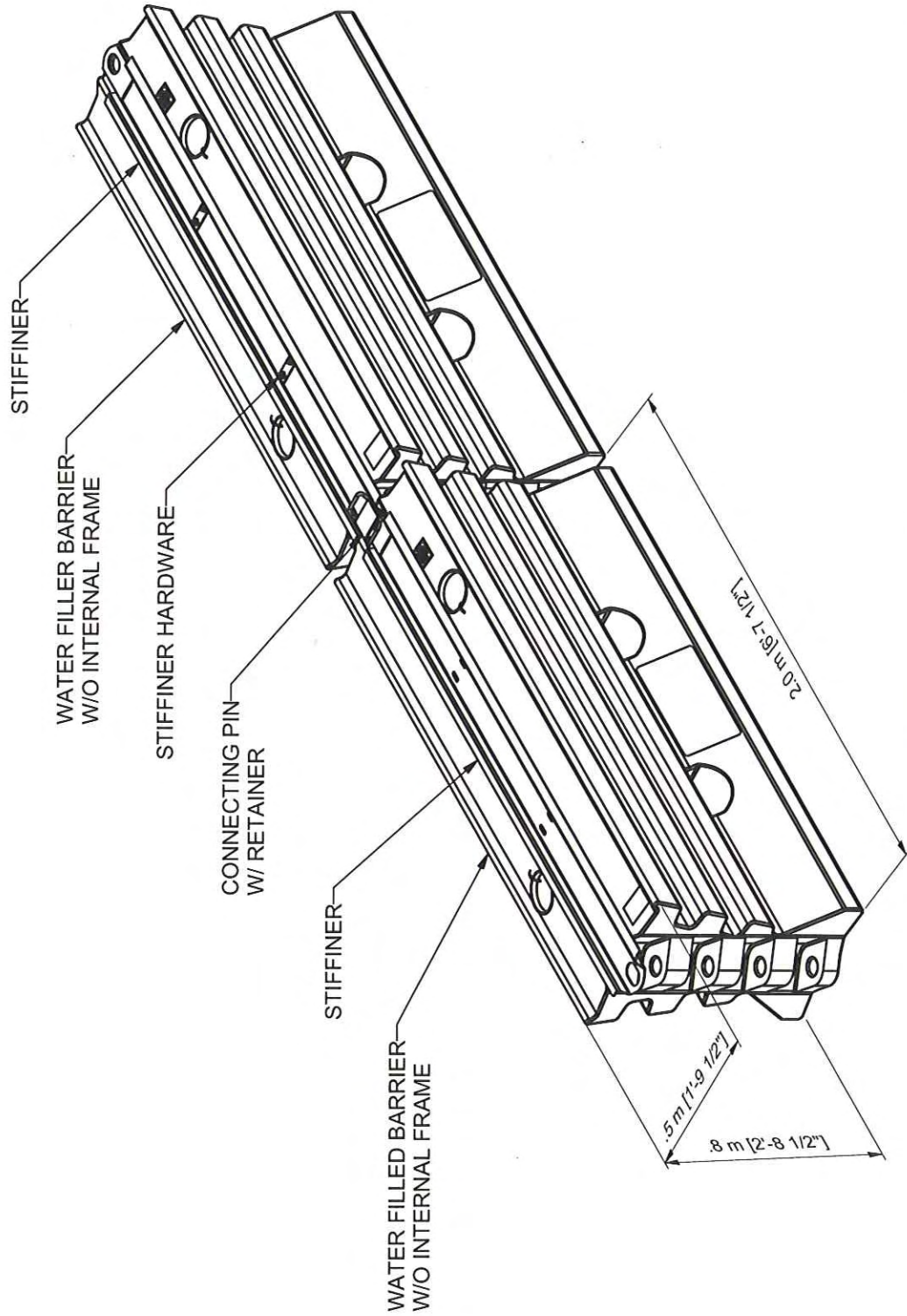
	ENERGY ABSORPTION SYSTEMS, INC. ENGINEERING AND RESEARCH DEPARTMENT	
ACZ-350 SECTION 2		
DRAWN: aaron.cox	DATE: 11/13/2008	CHECKED: 
DESIGNED: aaron.cox	DATE:	
CHECKED:	DATE:	
APPROVED:	DATE:	
D.U.:	DATE:	
UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN INCHES DIMENSIONS ACCORDING TO ASME Y14.5M-1994 UNLESS OTHERWISE SPECIFIED.		
DRAWING: 		SHEET: 1 of 1

Figure 4



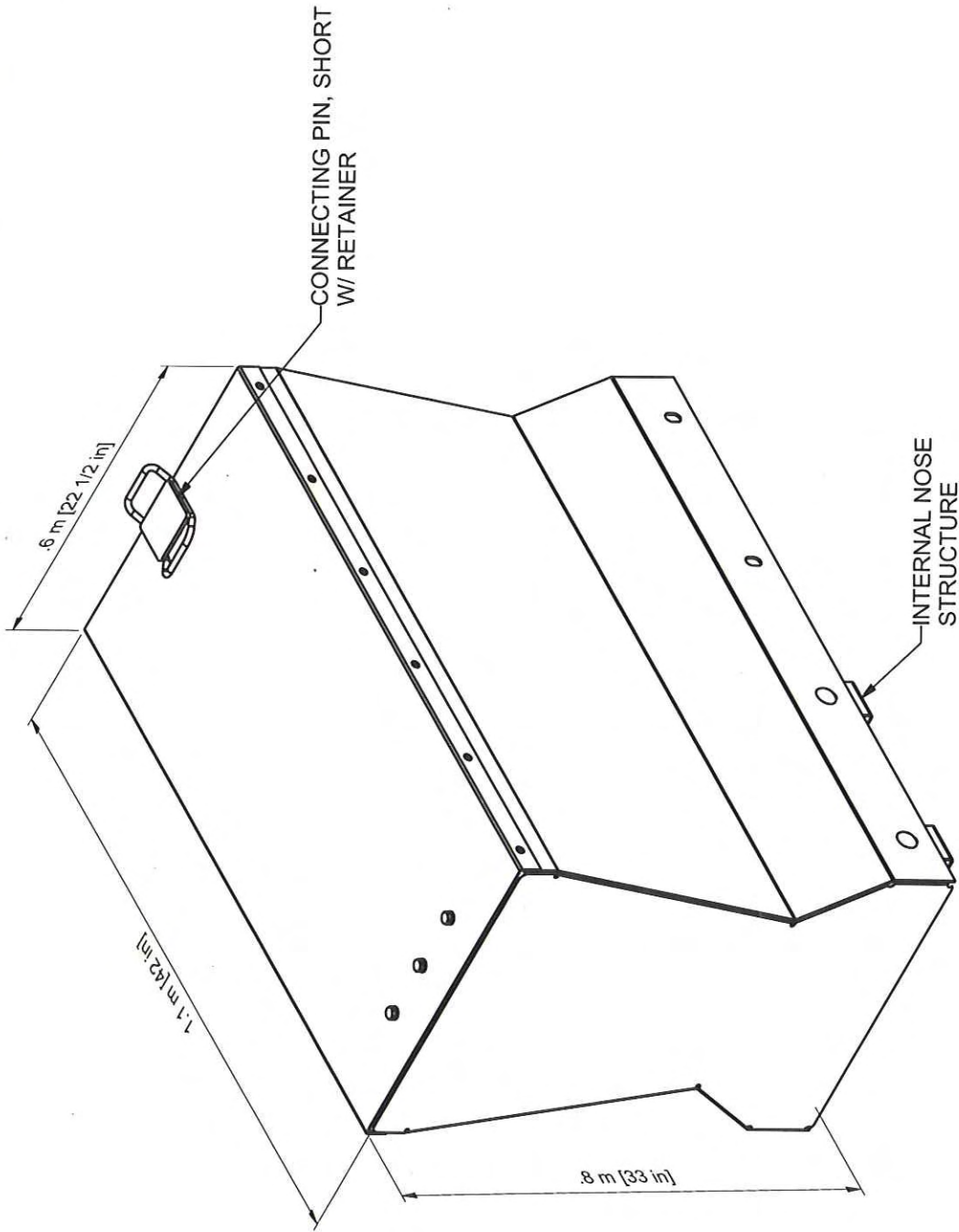
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UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN INCHES. DIMENSIONS ACCORDING TO ASME Y14.5M-1994 UNLESS OTHERWISE SPECIFIED.		
DRAWING:		SHEET: 1 of 1
ACZ-350 TRANSITION ASSY		REV

Figure 3



DATE	11/12/2008	DATE	
DESIGNED	aaron.cox	DATE	
CHECKED	aaron.cox	DATE	
APPROVED		DATE	
D.C.		DATE	
UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN INCHES. DIMENSIONS ACCORDING TO ASME Y14.5M-1994 UNLESS OTHERWISE SPECIFIED.			
DRAWN: aaron.cox		DATE	11/12/2008
DESIGNED: aaron.cox		DATE	
CHECKED: aaron.cox		DATE	
APPROVED:		DATE	
D.C.:		DATE	
ENERGY ABSORPTION SYSTEMS, INC. ENGINEERING AND RESEARCH DEPARTMENT		DRAWING	1 of 1
ACZ-350 SECTION 1		SHEET	1 of 1
		REV	

Figure 2





DRAWN: aaron.cox	DATE: 11/12/2008	 ENERGY ABSORPTION SYSTEMS, INC. ENGINEERING AND RESEARCH DEPARTMENT	ACZ-350 NOSE ASSY	DRAWING: 	SHEET: 1 of 1	REV:
DESIGNED: aaron.cox	DATE:					
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APPROVED:	DATE:					
DATE:	DATE:					
UNLESS OTHERWISE NOTED, ALL DIMENSIONS ARE IN INCHES. DIMENSIONS ACCORDING TO ASME Y14.5M-1994 UNLESS OTHERWISE SPECIFIED.						

Figure 5

NCHRP 350
TEST MATRIX

→ = 820C
← = 2000P

* F FOR TL-2 & TL-3; G FOR TL-1

TERMINALS & CRASH CUSHIONS
NONREDIRECTIVE GATING

TL-3 (100 km/h = 62.1 mph)

ACZ-350 SYSTEM

PASSED

TEST 3-40
820C/100 km/h/0°
C,D,F*,H,I,(J),K,N



PASSED

TEST 3-41
2000P/100km/h/0°
C,D,F*,H,I,(J),K,N



PASSED

TEST 3-44
2000P/100km/h/20°
C,D,F*,K,N

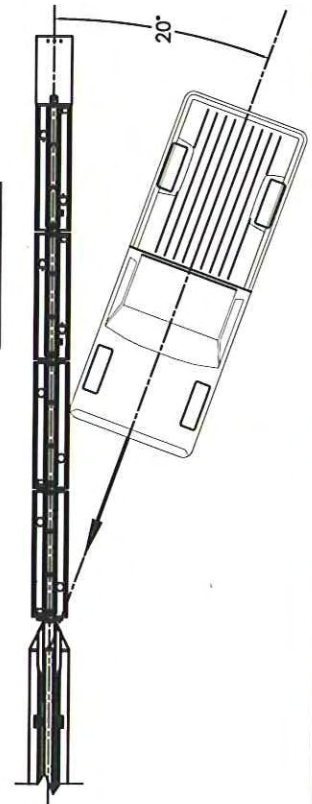
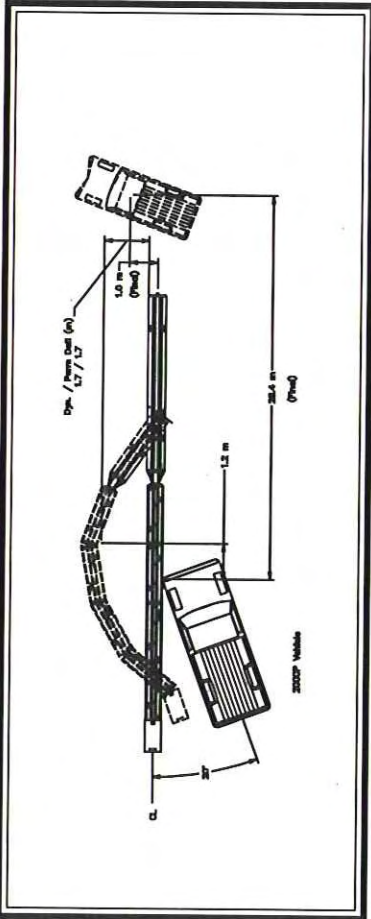
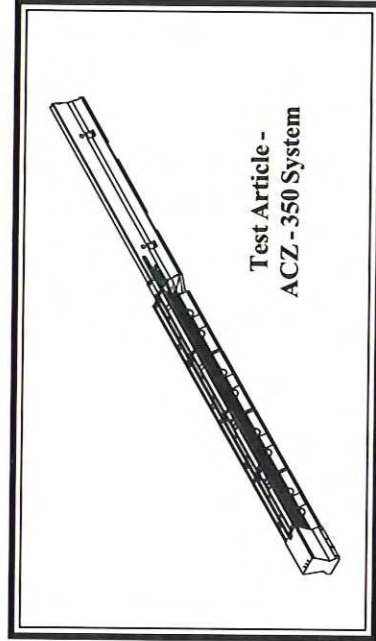


Figure 6



t = 0.000 sec t = 0.160 sec t = 0.320 sec t = 0.480 sec t = 0.640 sec t = 0.800 sec

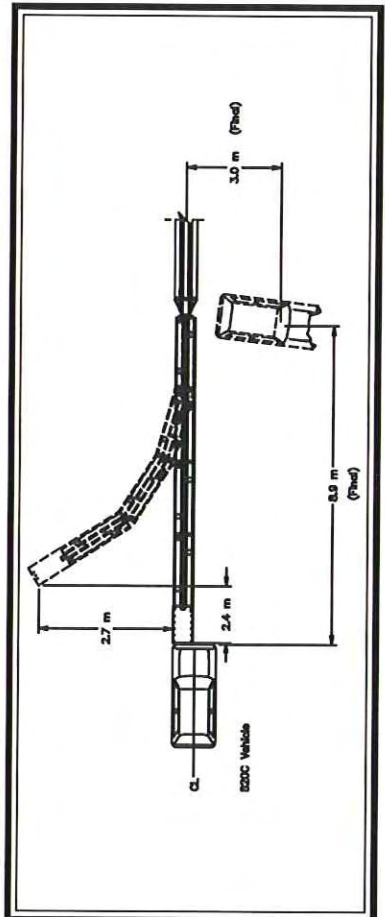
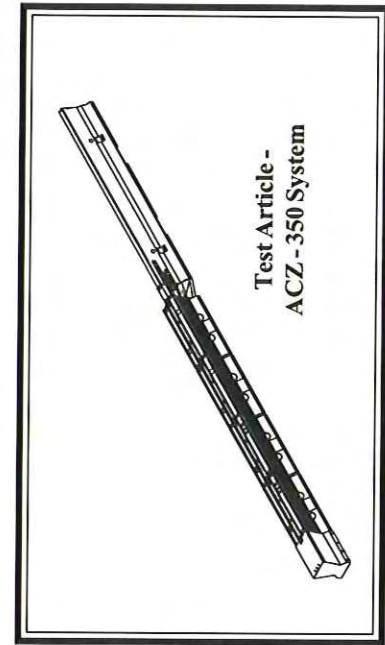


General Information	
Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-44 modified
Test No.	01-4317-003
Date	12/4/08
Test Article Type	Energy Absorption System
Installation Length,	ACZ - 350 System
Material and key elements	9.0 m - (4) segment total, pinned and freestanding w/ steel nose Polyethylene plastic segments (4 water filled), first two w/o frame and steel side straps, last two with, 14 ga hollow steel nose, transition to (3) 3 m freestanding PCMB with last section anchored
Foundation Type and Condition	Segment Length x Width x Height: (2021 mm x 533 mm x 813 mm) Portland Cement Concrete, clean and dry, unanchored
Test Vehicle Type	Production Model
Designation	2000P
Model	1988 Chevrolet C2500 Pickup
Mass (kg) Curb	1907
Test inertial	2000
Dummy	N/A
Gross Static	2000
Impact Conditions	
Speed (km/h)	96.4
Angle (deg)	20
Impact Severity (kJ)	717.0
Exit conditions	
Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	10.5
x-direction	6.9
y-direction	-18.4
Ridedown Acceleration (g's)	
x-direction	-12.0
y-direction	43.3
European Committee for Normalization (CEN) Values	
THIV (km/h)	31.0
PHD (g's)	1.8
ASI	-17.5
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	24.9
Maximum Pitch Angle	-59.5
Maximum Yaw Angle	1.7
Test Article Deflections (m)	
Dynamic	1.7
Permanent	1.7
Vehicle Damage (Primary Impact)	
Exterior	
VDS	FL-4
CDC	11FLEW4
Interior	
VCDI	AS1020000
Maximum Deformation (mm)	195

Figure 11. Summary of Results - ACZ - 350 System Test 01-4317-003



t = 0.00 sec t = 0.129 sec t = 0.258 sec t = 0.387 sec t = 0.516 sec t = 0.968 sec



General Information

Test Agency
 Test Designation
 Test No.

E-TECH Testing Services, Inc.
 NCHRP 350 Test 3-40
 01-4317-002

Date
 Test Article Type

11/6/08

Installation Length,

Energy Absorption System
 ACZ - 350 System

9.0 m - (4) segment total,
 pinned and freestanding
 w/ steel nose

Material and key elements

Polyethylene plastic segments
 (4 water filled), first two w/o frame and
 steel side straps, last two with, 14 ga
 hollow steel nose, transition to (3) 3 m
 freestanding PCMB with last section
 anchored

Foundation Type and Condition

Segment Length x Width x Height:
 (2021 mm x 533 mm x 813 mm)
 Portland Cement Concrete,
 clean and dry, unanchored

Test Vehicle

Type
 Designation
 Model

Production Model
 820C
 1993 Ford Festiva

Mass (kg)
 Curb
 Test inertial
 Dummy
 Gross Static

821
 816
 75
 891

Impact Conditions

Speed (km/h)
 Angle (deg)
 Impact Severity (kJ)

99.0
 0
 308.5

Exit conditions

Speed (km/h)
 Angle (deg - veh. c.g.)

N/A
 N/A

Occupant Risk Values

Impact Velocity (m/s)
 x-direction
 y-direction

11.9
 -0.6

Ridedown Acceleration (g's)

x-direction
 y-direction

-12.5
 -3.6

European Committee for Normalization (CEN) Values

THIV (km/h)
 PHD (g's)

44.2
 12.5

ASI

1.1

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle
 Maximum Pitch Angle
 Maximum Yaw Angle

20.1
 -43.5
 -244.9

Test Article Deflections (m)

Dynamic
 Permanent

2.7
 2.7

Vehicle Damage (Primary Impact)

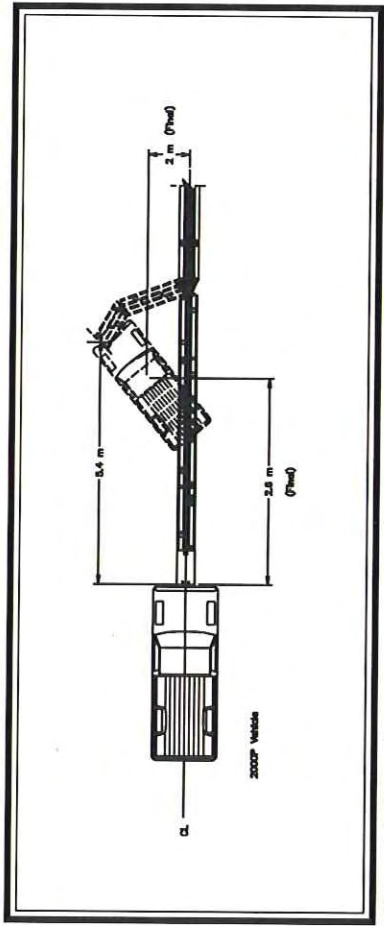
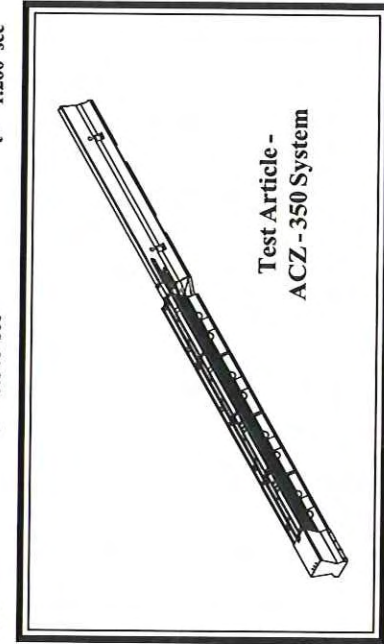
Exterior
 VDS
 CDC
 Interior
 VCDI
 Maximum Deformation (mm)

FD-4
 12FDEW4
 AS0001000
 21 mm

Figure 1. Summary of Results - ACZ - 350 System Test 01-4317-002



t = 0.000 sec t = 0.210 sec t = 0.420 sec t = 0.630 sec t = 0.840 sec t = 1.260 sec



General Information		
Test Agency	E-TECH Testing Services, Inc.	
Test Designation	NCHRP 350 Test 3-41	
Test No.	01-4317-001	
Date	10/30/08	
Test Article Type	Energy Absorption System	
Installation Length,	ACZ - 350 System	
Material and key elements	9.0 m - (4) segment total, pinned and freestanding w/ steel nose	
Foundation Type and Condition	Polyethylene plastic segments (4 water filled), first two w/o frame and steel side straps, last two with, 14 ga hollow steel nose, transition to (3) 5 m freestanding PCMB with last section anchored	
Test Vehicle	Segment Length x Width x Height: (2021 mm x 533 mm x 813 mm)	
Type	Portland Cement Concrete, clean and dry, unanchored	
Designation	Production Model	
Model	2000P	
Mass (kg)	1988 Chevrolet C2500 Pickup	
Curb	1853	
Test inertial	1995	
Dummy	N/A	
Gross Static	1995	
Impact Conditions		
Speed (km/h)	98.3	
Angle (deg)	0	
Impact Severity (kJ)	744.0	
Exit conditions		
Speed (km/h)	N/A	
Angle (deg - veh. c.g.)	N/A	
Occupant Risk Values		
Impact Velocity (m/s)		
x-direction	9.9	
y-direction	-0.3	
Ridedown Acceleration (g's)		
x-direction	-11.1	
y-direction	-5.7	
European Committee for Normalization (CEN) Values		
PHD (km/h)	35.6	
THIV (g's)	11.2	
ASI	0.9	
Post-Impact Vehicular Behavior (deg - rate gyro)		
Maximum Roll Angle	-7.6	
Maximum Pitch Angle	20.0	
Maximum Yaw Angle	-39.2	
Test Article Deflections (m)		
Dynamic	5.4	
Permanent	5.4	
Vehicle Damage (Primary Impact)		
Exterior		
VDS	FD-4	
CDC	I2FDEW4	
Interior		
VCDI	AS0000000	
Maximum Deformation (mm)	14	

Figure 6. Summary of Results - ACZ - 350 System Test 01-4317-001