



U.S. Department
of Transportation

**Federal Highway
Administration**

October 27, 2006

400 Seventh St., S.W.
Washington, D.C. 20590

In Reply Refer To:
HSA-10/CC-87B

Mr. Barry Stephens, P.E.
Sr. Vice President, Engineering
Energy Absorption Systems, Inc.
3617 Cincinnati Avenue
Rocklin, CA 95678

Dear Mr. Stephens:

In your October 11 letter, you requested acceptance of a modified version of your previously accepted QUEST crash cushion called the QUEST 70/100 system. To support this request, you supplied test reports prepared by E-TECH Testing Services, Inc. that described the new system as well as the full-scale crash tests you conducted.

The QUEST 70/100 system is a re-directive, non-gating, modular crash cushion having a test level 2 (TL-2) nominal effective length of 17.65 ft (5.38m) and a TL-3 nominal effective length of 23.65 ft (7.21m). The QUEST 70/100 is 32 inches (813mm) tall. The nominal backup width ranges from 24 inches (610mm) to 36 inches (915mm). Its main components include a ground anchored back-up assembly, two ground-anchored front anchors, two front rails, two rear rails, a nose, a trigger, a sled, a diaphragm, and panel assemblies. Essentially the QUEST 70/100 is longer than the original QUEST and uses laminated sheet metal "peel straps" rather than the solid energy absorbing straps in the original QUEST. The weight of the sled was also reduced.

Enclosure 1 shows the component parts of both the TL-2 and TL-3 QUEST models.

Testing of the QUEST 70/100 system was conducted on concrete foundations, although the original QUEST system was tested and accepted for asphalt applications. The QUEST 70/100 and the original QUEST system share identical front anchors and backups, with the same type and number of anchors. We agree that the asphalt anchoring system of the original QUEST is suitable for use on the QUEST 70/100 system without re-testing. For some tests, the unit was freestanding and for others it was butted directly up against a simulated rigid hazard. When anchored to concrete, the reported foundation must be at least 8 inches (203mm) thick and 30 of your MP-3 anchors (19mm diameter, B7, all-threaded) are specified with an embedment depth of at least 5.5 inches (140mm). The recommended nominal compressive strength of the concrete must be at least 27.6 MPa. When anchored to asphalt, the foundation must be at least 6 inches (150mm) thick over 6 inch (150mm) thick compacted sub-base and 38 of your MP-3 long-bolts (19mm diameter, B7, all-thread) are specified with an embedment depth of at least 16.5 inches (420mm).



The QUEST 70/100 system is designed to be where bi-directional traffic is present. You submitted drawings depicting transitions to w-beam and thrie-beam guardrail as well as "New Jersey" and vertically faced concrete walls. We have noted that these transitions are virtually identical to those validated in other testing programs previously accepted by the Federal Highway Administration (FHWA). We agree that additional crash testing is not required on the transition components.

Crash testing was successfully conducted for all eight certification tests recommended in the National Cooperative Highway Research Program (NCHRP) Report 350 for redirecting, non-gating crash cushions. These tests were conducted at TL-2 and TL-3 impact speeds. The TL-2 tests included 2-30, 31, 32, 33, 36, 37, 38, and 39. The TL-3 tests included 3-30, 31, 32, 33, 36, 37, 38, and 39. Test 3-32 was also conducted on a 36 inch (915 mm) wide model of QUEST 70/100 system since this test has traditionally been the most demanding on a wider system. Each test set-up and its results are described in the enclosed test summary reports shown in Enclosure 2.

Your QUEST 70/100 system meets the evaluation criteria for the NCHRP Report 350 re-directive, non-gating crash cushion at TL-2 and TL-3 impact conditions and may be used on the National Highway System when such use is acceptable to the contracting authority. It may be configured with back-up widths from 24 inches (610mm) to 36 inches (915mm). The transition designs are acceptable when the QUEST 70/100 is connected to w-beam, thrie-beam, New Jersey or vertically faced concrete barrier. Further, the QUEST 70/100 can be anchored to concrete or asphalt surfaces if these surfaces duplicate the minimum anchoring foundations noted above.

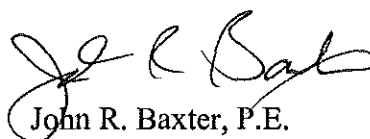
Please note the following standard provisions that apply to the FHWA letters of acceptance:

- Our acceptance is limited to the crashworthiness characteristics of the crash cushion.
- Any additional 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.
- To prevent misunderstanding by others, this letter of acceptance, designated as number CC-87B 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 crash cushion system design is patented and considered proprietary. When proprietary devices are *specified by a highway agency* for use on Federal-aid projects they: (a) must be supplied through competitive bidding with equally suitable unpatented items; (b) the highway agency must certify that they are essential for synchronization with 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.

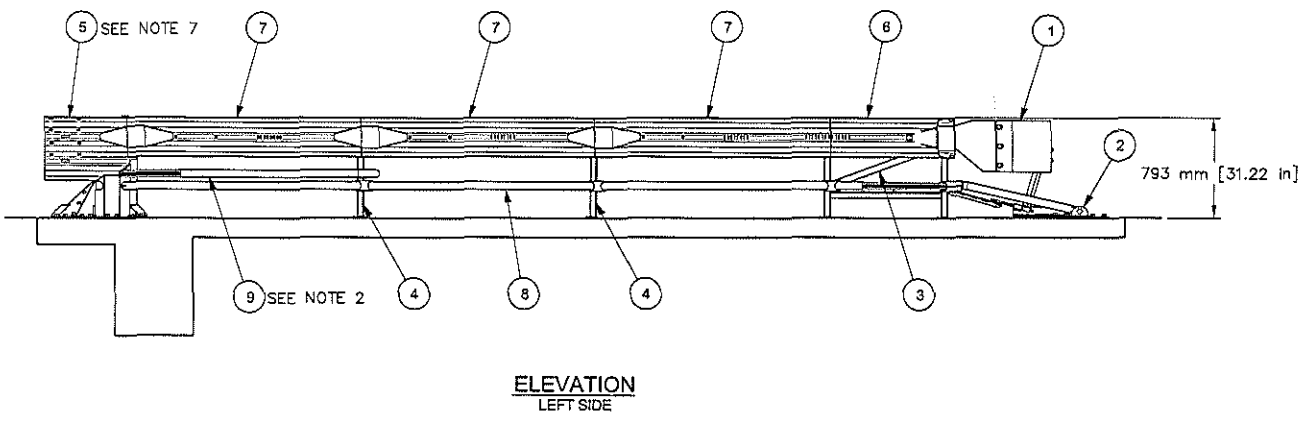
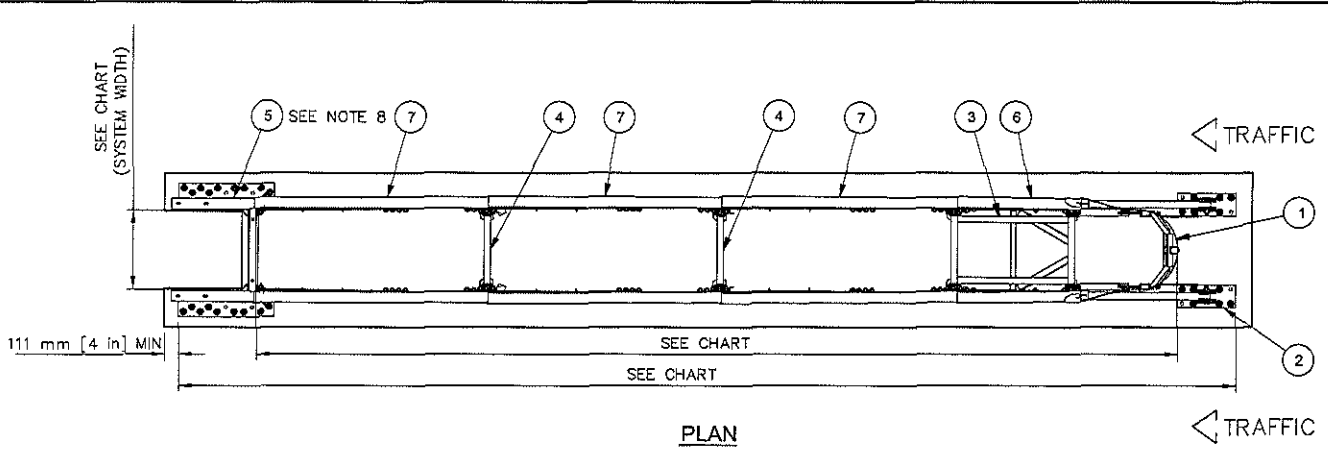
- This acceptance letter shall not be construed as authorization or consent by the FHWA to use, manufacture, or sell any patented device for which the applicant is not the patent holder. The acceptance letter is limited to the crashworthiness characteristics of the candidate device, and the FHWA is neither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

Sincerely yours,



John R. Baxter, P.E.
Director, Office of Safety Design
Office of Safety

2 Enclosures



NOTES:

- IN COMPLIANCE WITH THE AASHTO 2002 ROADSIDE DESIGN GUIDE, MANUFACTURER RECOMMENDS REMOVAL OF ALL CURBS AND ISLANDS TO ENSURE PROPER IMPACT PERFORMANCE.
- PROVISION SHALL BE MADE FOR REAR RAILS TO SLIDE REARWARD UPON IMPACT 1.82m [6' 0"] MIN.
- CAUTION: THE QUEST PRODUCT MUST BE CORRECTLY ANCHORED FOR PROPER IMPACT PERFORMANCE. ATTACH PRODUCT USING ONE OF THE FOLLOWING: (QTY. 30) 178 [7] STUDS MAY BE USED TO ATTACH PRODUCT TO 28 MPa [4000 PSI] MIN P.C. CONCRETE PER THE FOLLOWING MINIMUMS.**
 A) 152 [6.00] REINFORCED PAD PER REFERENCE DRAWING 3562015-0000.
 B) 203 [8.00] NON-REINFORCED ROADWAY, MEASURING AT LEAST 3.66m [12' 0"] WIDE BY 15.24m [50' 0"] LONG, SEE DWG 3562007-0000.
 C) 180 [7.00] REINFORCED DECK STRUCTURE, SEE DWG 3562007-0000. (QTY 38) 457 [18] THREADED RODS MAY BE USED TO INSTALL PRODUCT ON ASPHALT.**
 ** REFER TO THE QUEST INSTALLATION INSTRUCTIONS FOR FOUNDATION SPECIFICATIONS.
- SEE THE "QUEST PRODUCT MANUAL" FOR A DESCRIPTION OF ITS IMPACT PERFORMANCE CHARACTERISTICS AND DESIGN LIMITATIONS BEFORE PLACING A PRODUCT AT A GIVEN SITE. INFORMATION AND COPIES OF ABOVE MANUAL ARE AVAILABLE BY CALLING CUSTOMER SERVICE DEPARTMENT AT (888) 323-6374.
- WHERE NECESSARY, THE CUSTOMER SHALL SUPPLY AN ADEQUATE TRANSITION FROM THE QUEST PRODUCT TO THE OBJECT BEING SHIELDED.
- ANCHOR BOLTS NOT INCLUDED IN MODEL NUMBER, ORDER SEPARATELY.
- STEEL BACKUP AND CONCRETE PAD SPECIFICALLY DESIGNED TO NEST AROUND 610 WIDE HAZARDS, INSTALL ACCORDINGLY TO ENSURE PROPER IMPACT PERFORMANCE.

Bays	Width	System Length	Effective Length	Max Design Speed
3	24"	21'-2"	17"-8"	70 km/h [44 mph]
4	24"	27'-2"	23'-8"	100 km/h [62 mph]
3	36"	21'-2"	17"-8"	70 km/h [44 mph]
4	36"	27'-2"	23'-8"	100 km/h [62 mph]

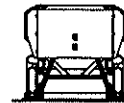
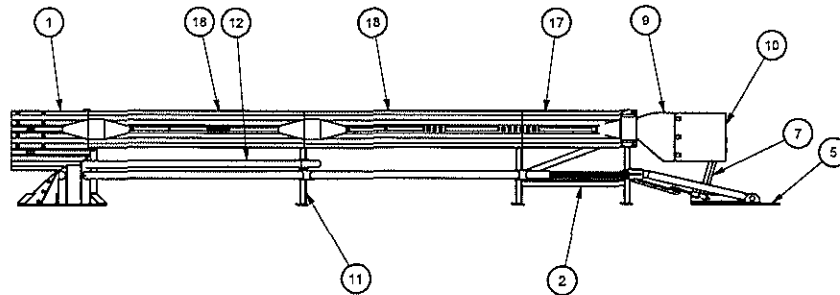
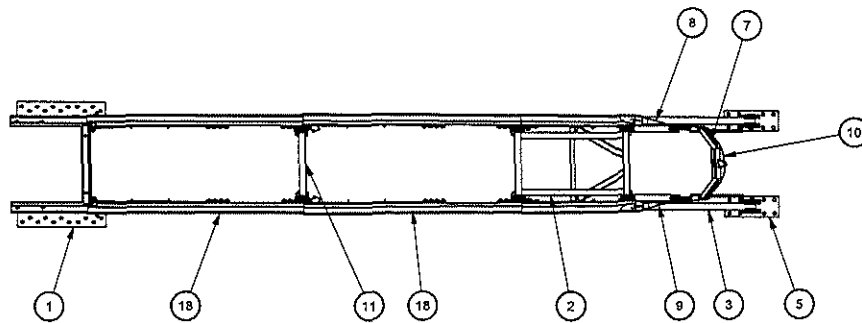
- 1 NOSE
- 2 FRONT ANCHOR
- 3 BAY 1
- 4 DIAPHRAGM
- 5 BACKUP
- 6 BAY 1 PANEL
- 7 BAY 2-4 PANEL
- 8 SHAPER RAIL
- 9 REAR RAIL

Revision	Date	Rev	By	Chk.	App.

D. Kohfeld	7/24/2006
D. Wilkinson	12/27/2005
JME	9/12/2006
K. Looney	9/12/2006

UNIDIRECTIONAL

QUEST® 70/100



PARTS LIST			
ITEM	STOCK NO.	DESCRIPTION	QTY.
1	2762020-0000	BACKUP_24,QUEST,G	1
2	3562013-0000	SUPPORT FRAME ASSY,QUEST,DCM	1
3	276201L-0000	SHAPER RAIL,L,QUEST 80,G	1
4	276201R-0000	SHAPER RAIL,R,QUEST 80,G	1
5	2762015-0000	ANCHOR,FRONT,QUEST,G	2
6	2762007-0000	TRIGGER STRAP,QUEST,G	2
7	3562014-0000	TRIGGER ASSY,QUEST,DCM	1
8	2762024-0000	NOSE TRANSITION,R,QUEST,G,PT	1
9	2762025-0000	NOSE TRANSITION,L,QUEST,G,PT	1
10	2762026-0000	NOSE,QUEST,G,PT	1
11	3562016-0000	DIAPHRAGM ASSY,QUEST CEN	1
12	2762055-0000	REAR RAIL,QUEST,UNCRIMPED,G	2
13	2762043-0000	STRAP,PEEL,REAR,QUEST CEN	2
14	2762045-0000	STRAP,PEEL,BAY 2,QUEST CEN	2
15	2762044-0000	FLT ST, 1/4X2 13/16X10 7/16,W/HOLES,G	2
16	2762047-0000	FLT ST 1/4X4X14,W/SLOTS,G	2
17	2762049-0000	PANEL,BAY 1,QUEST,G	2
18	2762048-0000	PANEL,BAYS,QUEST,DCM,G	4
19	2762050-0000	BRACE,PANEL,QUEST CEN,G	4
20	2708943-0300	SCREW,PN,#6-32X1 1/2,PHIL,S	8
21	2708871-1000	WASHER,BAR,1/8X1 1/4X2,ROUNDED,G	8
22	2708291-0000	WASHER,FLAT,5/8 X 1 3/4, G	6
23	2708039-0300	WASHER,FLAT,#6X5/8X.030,S	16
24	2708161-0000	WASHER,BAR,2X2X1/4,G	2
25	2708022-0100	WASHER,FLAT,3/8 ID X1 3/16 OD,P,HRD	32
26	2704191-0000	NUT,HX,5/8,G,RAIL	54
27	2704341-0000	NUT,HX,3/4",GR DH	8
28	2704161-0000	NUT,HX,1,G	2
29	2704031-0000	NUT,HX,3/8,G	16
30	2704351-0000	NUT,HX,5/8,G,GR DH	6
31	2704771-0300	NUT,HX,#6-32,S	16
32	2701811-0000	BOLT,RAIL,5/8X1 1/4,G5,G	42
33	2699341-0000	BOLT,RAIL,5/8X2,G	12
34	2700011-0000	BOLT,HX,3/4X2,G5,G	4
35	2701014-0000	BOLT,HX,1X5,G8,G	2
36	2700541-0000	BOLT,HX,1X3 1/2,G5,G	2
37	2699081-0500	BOLT,HX,5/8X1 1/2,G5,G	6
38	2699251-0000	BOLT,HX,3/4X3 1/2,G5,G	2
39	2701221-0000	BOLT,HX,3/8X1,G2,G	16
40	2700651-0000	BOLT,HX,3/4X4,G5,G,ALL THRD	2
41	2705121-0000	RIVET,ST,SD08BS,3/16X1/2,DH	1
42	2735711-0000	DECAL,CAUTION,ALL PRODUCTS	1
43	2735712-4200	DECAL,PRODUCT,QUEST TL-2	1
44	2750043-0000	INSTALL INSTRUCTIONS,QUEST TL2	1
45	2735831-3500	MATERIAL SAFETY INFORMATION NOTICE	1

ASSEMBLY NO. TD35024-TL2



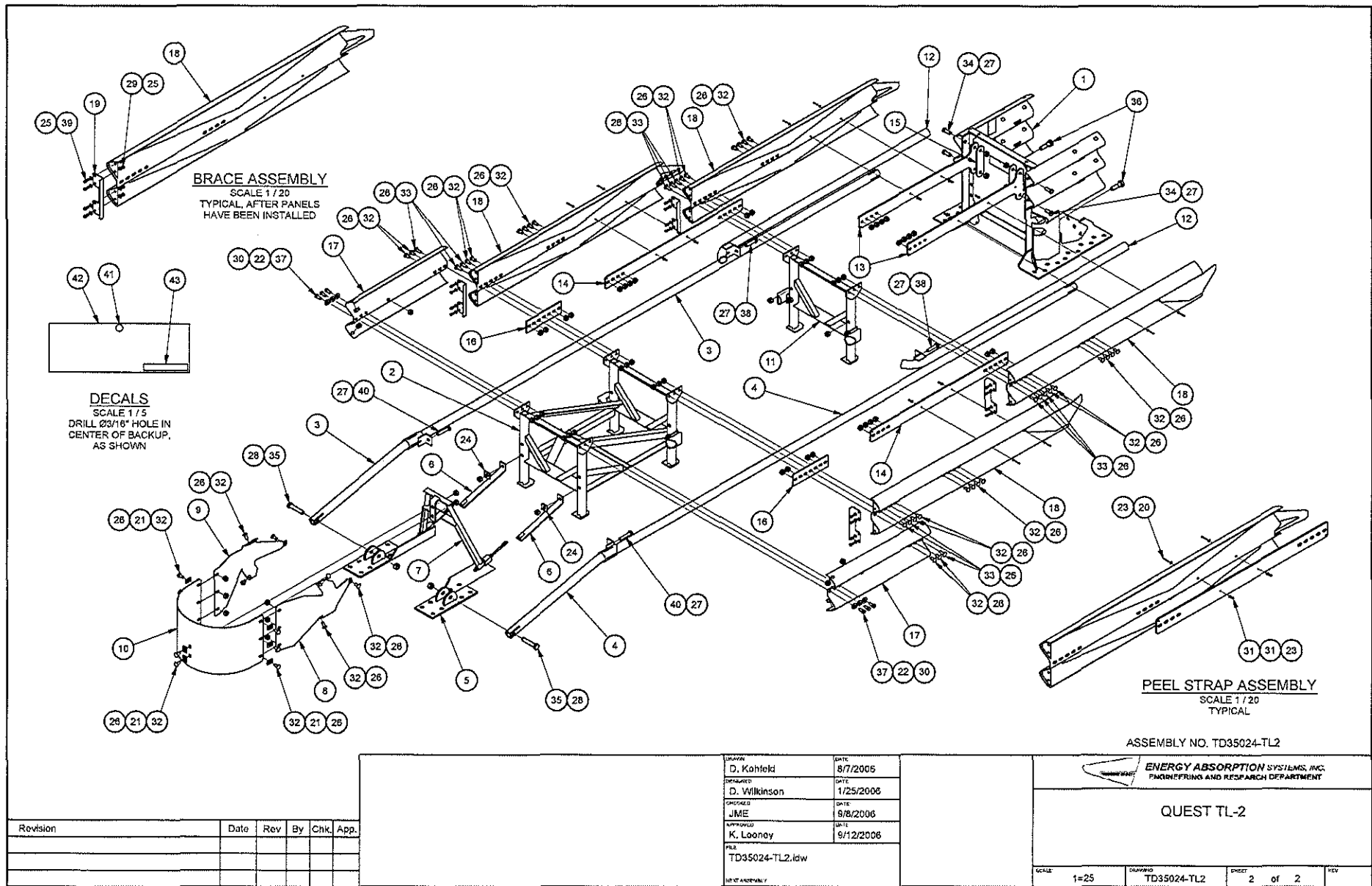
ENERGY ABSORPTION SYSTEMS, INC.
ENGINEERING AND RESEARCH DEPARTMENT

QUEST TL-2

SCALE: 1:1 DRAWING: TD35024-TL2 SHEET: 1 of 2 REV

Revision	Date	Rev	By	Chk.	App.

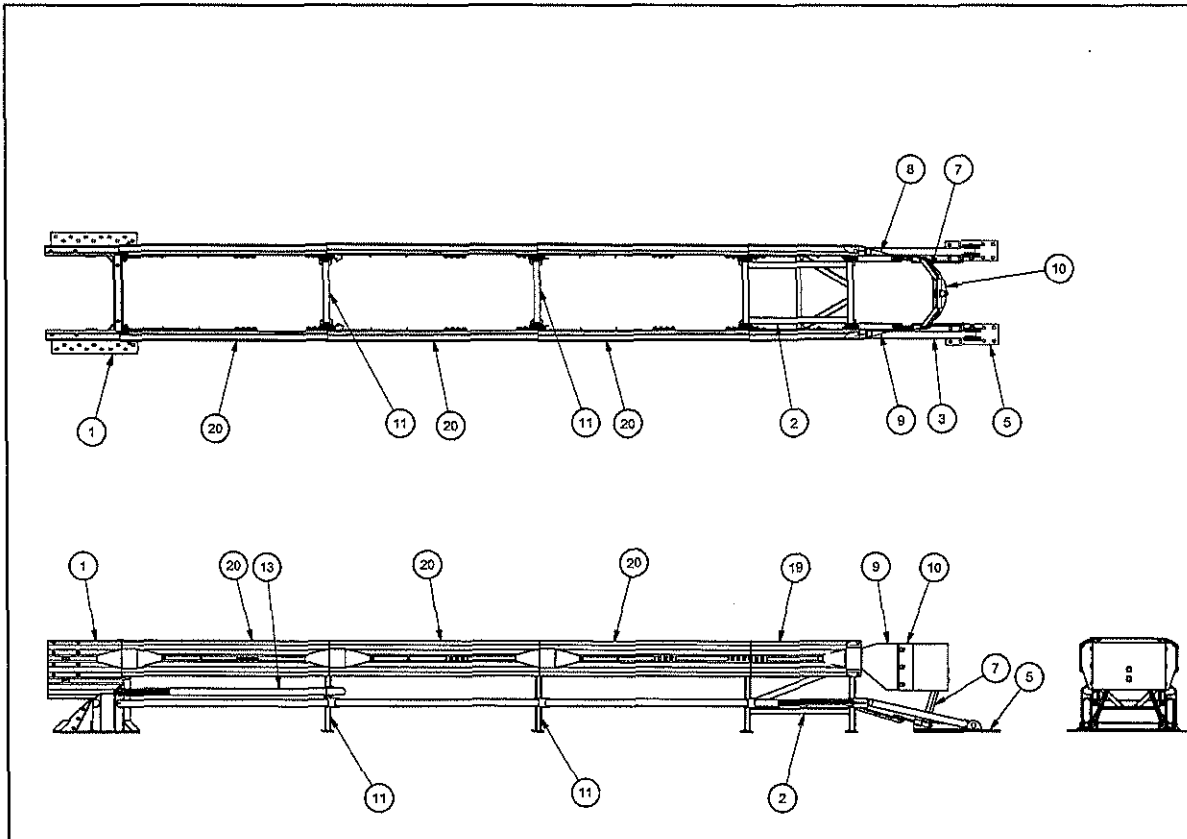
DESIGNED BY	D. Kohfeld	DATE	8/7/2006
DESIGNED DATE	D. Wilkinson	DATE	1/25/2006
CHECKED BY	JME	DATE	9/8/2005
APPROVED BY	K. Looney	DATE	9/12/2006
FILE	TD35024-TL2.idw		
REVISED BY			



Revision	Date	Rev	By	Chk	App.

DESIGNED	DATE
D. Kohfeld	8/7/2006
DRAWN	DATE
D. Wilkinson	1/25/2006
CHECKED	DATE
JME	9/8/2006
APPROVED	DATE
K. Looney	9/12/2006
FILE	
TD35024-TL2.ldw	
DWG BY AND/OR VAL	

ENERGY ABSORPTION SYSTEMS, INC. ENGINEERING AND RESEARCH DEPARTMENT			
QUEST TL-2			
SCALE	DRAWING	SHEET	REV
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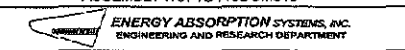


PARTS LIST			
ITEM	STOCK NO.	DESCRIPTION	QTY.
1	2762020-0000	BACKUP,24,QUEST,G	1
2	3562013-0000	SUPPORT FRAME ASSY,QUEST,DCM	1
3	276202L-0000	SHAPER RAIL,L,QUEST,CEN,G	1
4	276202R-0000	SHAPER RAIL,R,QUEST,CEN,G	1
5	2762015-0000	ANCHOR,FRONT,QUEST,G	2
6	2762007-0000	TRIGGER STRAP,QUEST,G	2
7	3562014-0000	TRIGGER ASSY,QUEST,DCM	1
8	2762024-0000	NOSE TRANSITION,R,QUEST,G,PT	1
9	2762025-0000	NOSE TRANSITION,L,QUEST,G,PT	1
10	2762026-0000	NOSE,QUEST,G,PT	1
11	3562016-0000	DIAPHRAGM ASSY,QUEST,CEN	2
12	2762017-0000	SHAPER,BACKUP,QUEST,G	2
13	2762041-0000	REAR RAIL,QUEST,DCM,G	2
14	2762043-0000	STRAP,PEEL,REAR,QUEST,CEN	2
15	2762045-0000	STRAP,PEEL,BAY 2,QUEST,CEN	2
16	2762046-0000	STRAP,PEEL,BAY 3,QUEST,CEN	2
17	2762044-0000	FLT ST, 1/4X2 13/16X10 7/16,W/HOLES,G	2
18	2762047-0000	FLT ST 1/4X4X14,W/SLOTS,G	2
19	2762049-0000	PANEL,BAY 1,QUEST,G	2
20	2762048-0000	PANEL,BAYS,QUEST,DCM,G	6
21	2762050-0000	BRACE,PANEL,QUEST,CEN,G	6
22	2706943-0300	SCREW,PN,#6-32X1 1/2,PHIL,S	12
23	2708871-1000	WASHER,BAR,1/8X1 1/4X2,ROUNDED,G	8
24	2708281-0000	WASHER,FLAT,5/8 X 1 3/4, G	6
25	2708039-0300	WASHER,FLAT,#6X5/8X.030,S	24
26	2708161-0000	WASHER,BAR,2X2X1/4,G	2
27	2708022-0100	WASHER,FLAT,3/8 ID X13/16 OD,P,HRD	49
28	2704191-0000	NUT,HX,5/8,G,RAIL	72
29	2704771-0300	NUT,HX,#6-32,S	24
30	2704341-0000	NUT,HX,3/4",GR DH	10
31	2704181-0000	NUT,HX,1,G	2
32	2704031-0000	NUT,HX,3/8,G	24
33	2704351-0000	NUT,HX,5/8,G,GR DH	6
34	2701811-0000	BOLT,RAIL,5/8X1 1/4,G5,G	54
35	2699341-0000	BOLT,RAIL,5/8X2,G	18
36	2700011-0000	BOLT,HX,3/4X2,G5,G	4
37	2701014-0000	BOLT,HX,1X5,G8,G	2
38	2700541-0000	BOLT,HX,1X3 1/2,G5,G	2
39	2699081-0500	BOLT,HX,5/8X1 1/2,G5,G	6
40	2699251-0000	BOLT,HX,3/4X3 1/2,G5,G	4
41	2701221-0000	BOLT,HX,3/8X1,G2,G	24
42	2700651-0000	BOLT,HX,3/4X4,G5,G,ALL THRD	2
43	2705121-0000	RIVET,ST,SD68BS,3/16X1/2,DH	1
44	2735711-0000	DECAL,CAUTION,ALL PRODUCTS	1
45	2735712-4000	DECAL,PRODUCT,QUEST DCM 100/110	1
46	2750042-0000	INSTALL INSTRUCTIONS,QUEST DCM	1
47	2735831-3500	MATERIAL SAFETY INFORMATION NOTICE	1

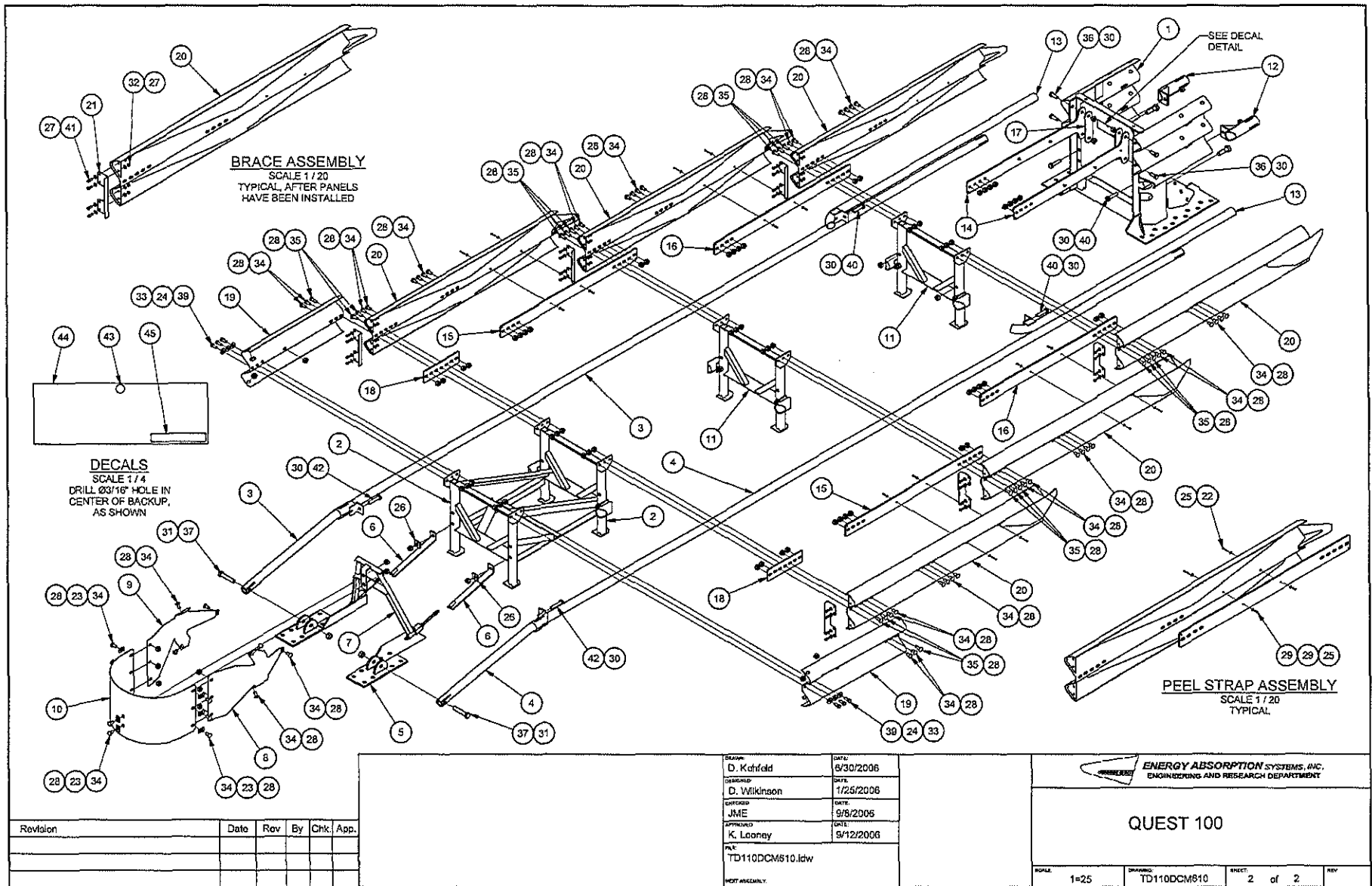
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Revision	Date	Rev	By	Chk.	App.

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QUEST 100



BRACE ASSEMBLY
SCALE 1 / 20
TYPICAL AFTER PANELS
HAVE BEEN INSTALLED

DECALS
SCALE 1 / 4
DRILL Ø3/16" HOLE IN
CENTER OF BACKUP,
AS SHOWN

PEEL STRAP ASSEMBLY
SCALE 1 / 20
TYPICAL

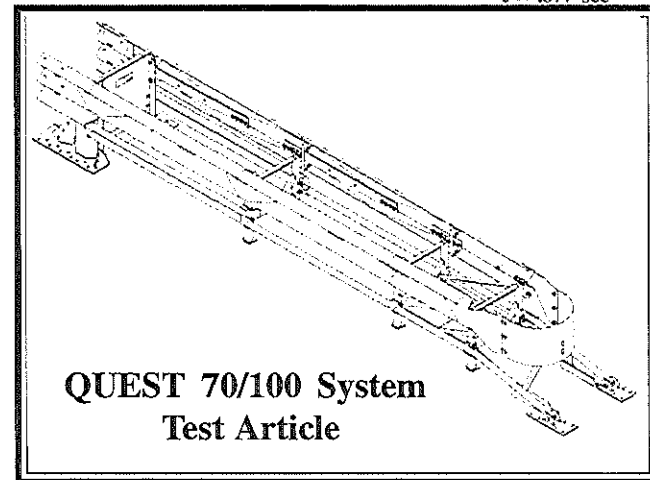
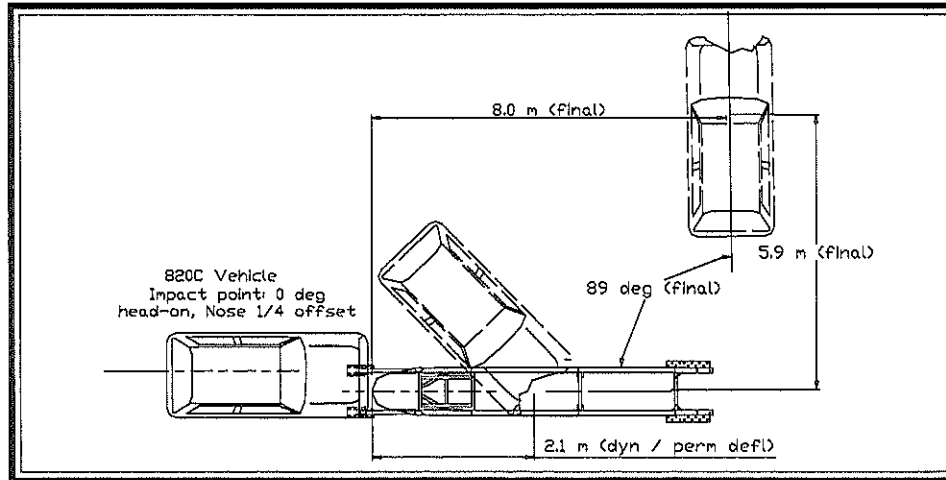
DESIGNED BY D. Kohfeld	DATE 6/30/2006
DESIGNED BY D. Wilkinson	DATE 1/25/2006
CHECKED BY JME	DATE 9/8/2006
APPROVED BY K. Looney	DATE 9/12/2006
PART NUMBER TD110DCM810.ldw	
NOT ASSEMBLY	

ENERGY ABSORPTION SYSTEMS, INC.
ENGINEERING AND RESEARCH DEPARTMENT

QUEST 100

Revision	Date	Rev	By	Chk	App.

SHEET 1=25	DRAWING TD110DCM810	SHEET 2 of 2	REV
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E-TECH Testing Services, Inc.

QUEST 70/100 Crash Test Results - 12 of 125

General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 2-30
 Test No. 01-2174-011
 Date 6/16/06

Test Article

Type Energy Absorption Systems, Inc.
 QUEST™ 70/100 System
 Installation Length 5.4 m (effective length)
 Material and key elements AASHTO M180 galvanized steel panels,
 ASTM A500 Rails, and A36 other
 Foundation and Anchoring Unreinforced 27.6 MPa concrete,
 clean and dry with (30) 19 mm x 178 mm
 ASTM A193 Grade B-7 threaded studs and
 MP-3 Anchoring System

Test Vehicle

Type Production Model
 Designation 820C
 Model 1991 Ford Festiva
 Mass (kg)
 Curb 806
 Test inertial 828
 Dummy 75
 Gross 903

Impact Conditions

Speed (km/h) 70.6
 Angle (deg) 0
 Impact Severity (kJ) 159.4

Exit conditions

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

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 10.4
 y-direction -0.7
 Ridedown Acceleration (g's)
 x-direction -16.2
 y-direction -3.8

European Committee for Normalization (CEN) Values

THIV (km/h) 37.6
 PHD (g's) 16.2
 ASI 1.2

Test Article Deflections (m)

Dynamic 2.1
 Permanent 2.1

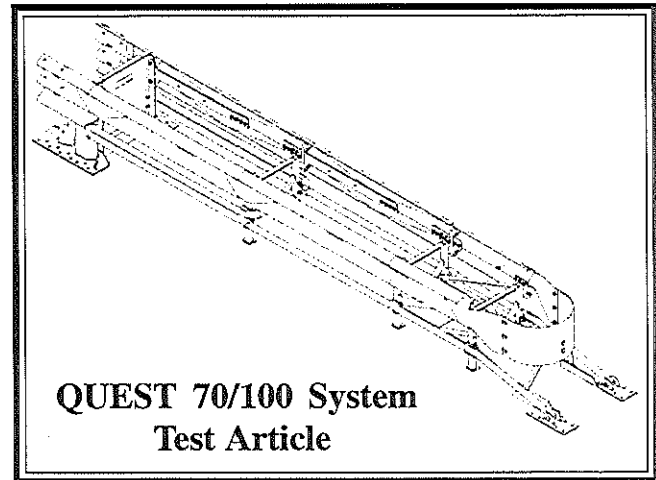
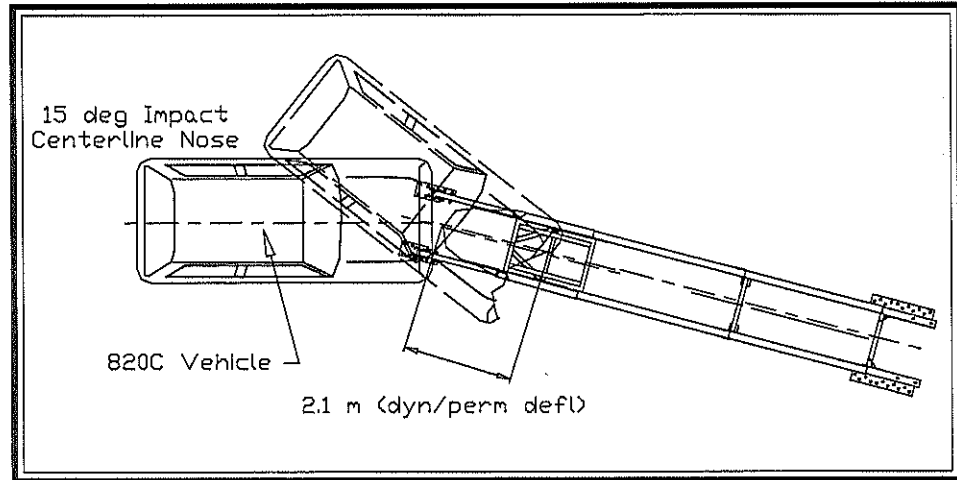
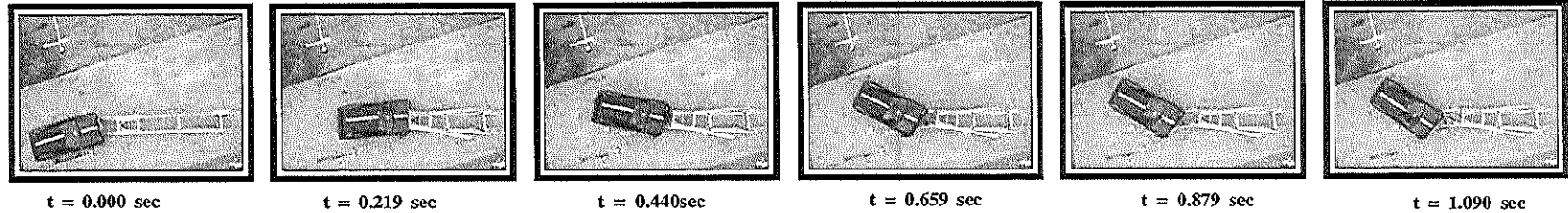
Vehicle Damage (Primary Impact)

Exterior
 VDS FC-3
 CDC 12FLEW3
 Interior
 VCDI AS0000000
 Maximum Deformation (mm) Negligible

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle 11.7
 Maximum Pitch Angle 8.1
 Maximum Yaw Angle 179.1

Figure 1. Summary of Results - QUEST 70/100 NCHRP 350 Test 2-30



E-TECH Testing Services, Inc.

QUEST 70/100 Crash Test Results - 24 of 125

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-32
Test No.	01-2174-010
Date	6/13/06
Test Article	
Type	Energy Absorption Systems, Inc.
.....	QUEST™ 70/100 System
Installation Length	5.4 m (effective length)
Material and key elements	AASHTO M180 galvanized steel panels,
.....	ASTM A500 Rails, and A36 other
Foundation and Anchoring	Unreinforced 27.6 MPa concrete,
.....	clean and dry with (30) 19 mm x 178 mm
.....	ASTM A193 Grade B-7 threaded studs and
.....	MP-3 Anchoring System

Test Vehicle

Type	Production Model
Designation	820C
Model	1989 Ford Festiva
Mass (kg)	
Curb	749
Test inertial	802
Dummy	75
Gross	877

Impact Conditions

Speed (km/h)	70.0
Angle (deg)	15
Impact Severity (kJ)	151.3

Exit conditions

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

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	11.3
y-direction	0.6
Ridedown Acceleration (g's)	
x-direction	-17.7
y-direction	-4.6

European Committee for Normalization (CEN) Values

THIV (km/h)	40.9
PHD (g's)	20.1
ASI	1.4

Test Article Deflections (m)

Dynamic	2.1
Permanent	2.1

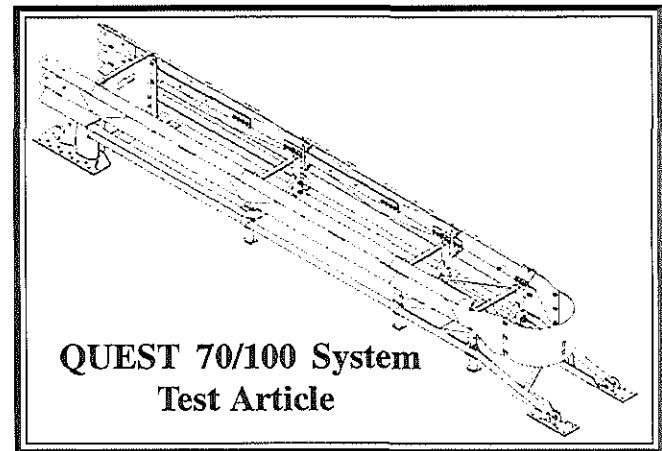
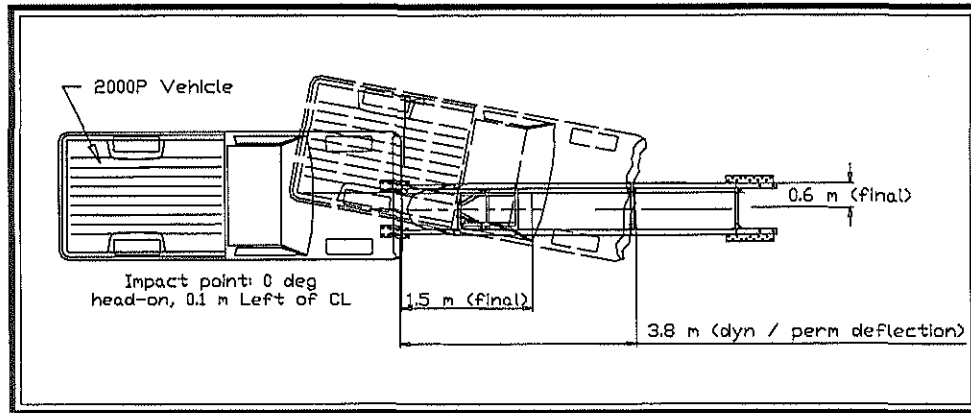
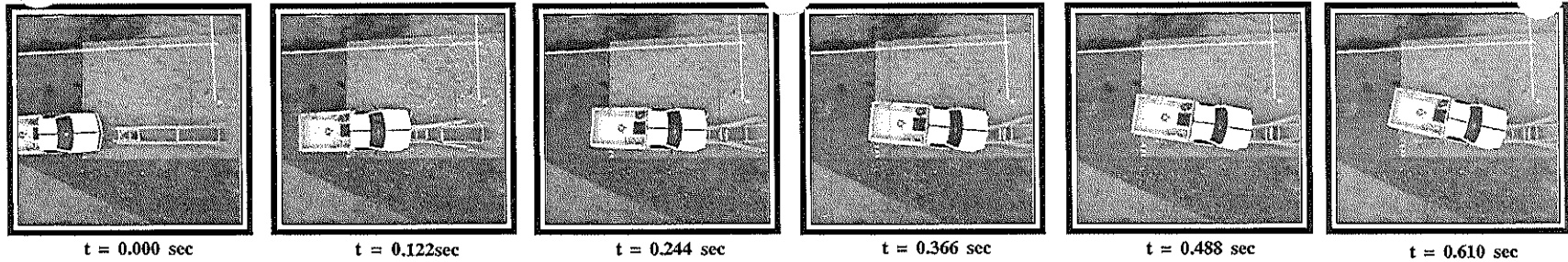
Vehicle Damage (Primary Impact)

Exterior	
VDS	FC-2
CDC	I2FCEW2
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	6.3
Maximum Pitch Angle	7.5
Maximum Yaw Angle	50.0

Figure 11. Summary of Results - QUEST 70/100 NCHRP 350 Test 2-32



E-TECH Testing Services, Inc.

QUEST 70/100 Crash Test Results - 18 of 125

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-31
Test No.	01-2174-008
Date	5/19/06

Test Article

Type	Energy Absorption Systems, Inc. QUEST™ 70/100 System
Installation Length	5.4 m (effective length)
Material and key elements	AASHTO M180 galvanized steel panels, ASTM A500 Rails, and A36 other
Foundation and Anchoring	Unreinforced 27.6 MPa concrete, clean and dry with (30) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System

Test Vehicle

Type	Production Model
Designation	2000P
Model	1993 Chevrolet C2500
Mass (kg)	
Curb	1889
Test inertial	1985
Dummy	N/A
Gross	1985

Impact Conditions

Speed (km/h)	71.7
Angle (deg)	0
Impact Severity (kJ)	393.5

Exit conditions

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

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	8.5
y-direction	0.1
Ridedown Acceleration (g's)	
x-direction	-10.4
y-direction	3.0

European Committee for Normalization (CEN) Values

THIV (km/h)	30.5
PHD (g's)	10.4
ASI	0.7

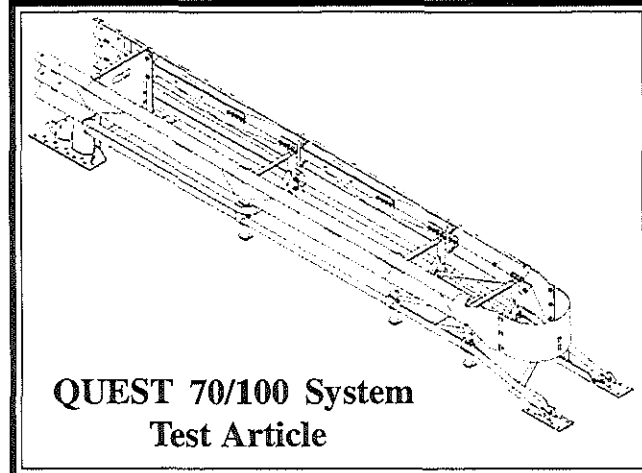
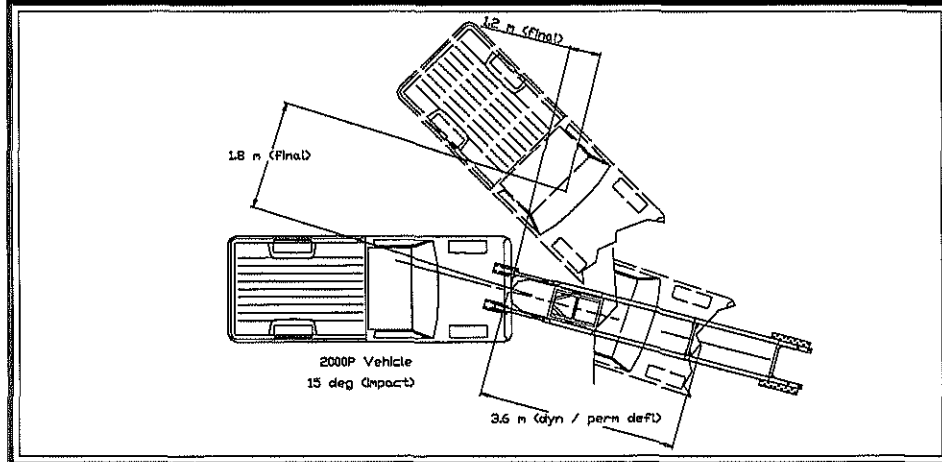
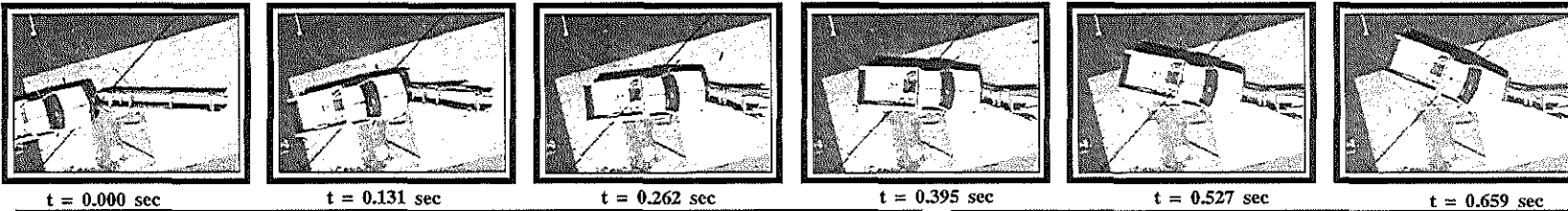
Test Article Deflections (m)

Dynamic	3.8
Permanent	3.8

Vehicle Damage (Primary Impact)

Exterior	
VDS	FC-2
CDC	12FCEW2
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	-3.2
Maximum Pitch Angle	12.3
Maximum Yaw Angle	23.1

Figure 6. Summary of Results - QUEST 70/100 NCHRP 350 Test 2-31



E-TECH Testing Services, Inc.

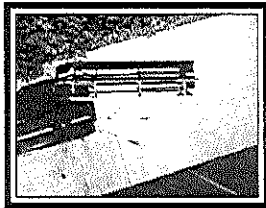
QUEST 70/100 Crash Test Results - 30 of 125

General Information

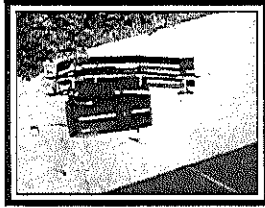
Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-33
Test No.	01-2174-014
Date	7/31/06
Test Article	
Type	Energy Absorption Systems, Inc.
	QUEST™ 70/100 System
Installation Length	5.4 m (effective length)
Material and key elements	AASHTO M180 galvanized steel panels, ASTM A500 Rails, and A36 other
Foundation and Anchoring	Unreinforced 27.6 MPa concrete, clean and dry with (30) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1988 Chevrolet C2500
Mass (kg)	
Curb	1897
Test inertial	2008
Dummy	N/A
Gross	2008
Impact Conditions	
Speed (km/h)	70.6
Angle (deg)	15
Impact Severity (kJ)	386.5

Exit conditions	
Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	8.8
y-direction	0.2
Ridedown Acceleration (g's)	
x-direction	-9.1
y-direction	2.4
European Committee for Normalization (CEN) Values	
THIV (km/h)	31.5
PHD (g's)	9.1
ASI	0.7
Test Article Deflections (m)	
Dynamic	3.6
Permanent	3.6
Vehicle Damage (Primary Impact)	
Exterior	
VDS	FC-2
CDC	12FCEW2
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	8.5
Maximum Pitch Angle	17.8
Maximum Yaw Angle	47.3

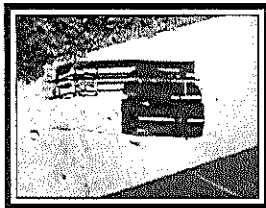
Figure 16. Summary of Results - QUEST 70/100 NCHRP 350 Test 2-33



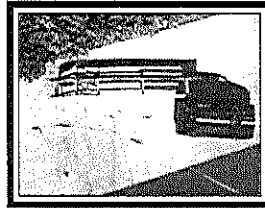
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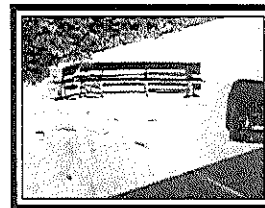
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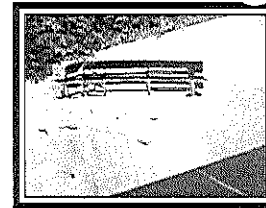
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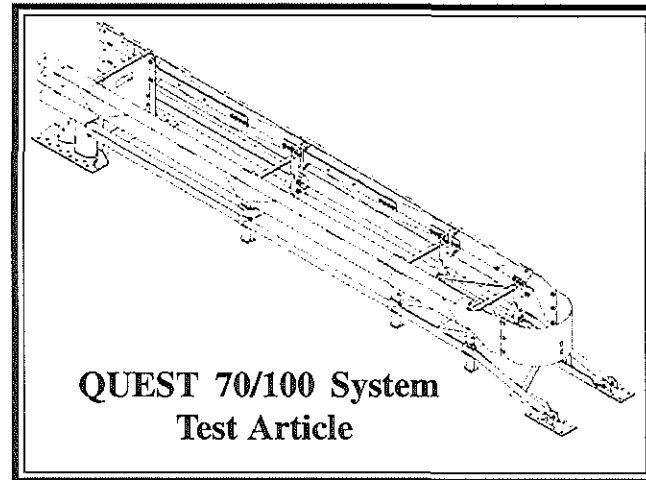
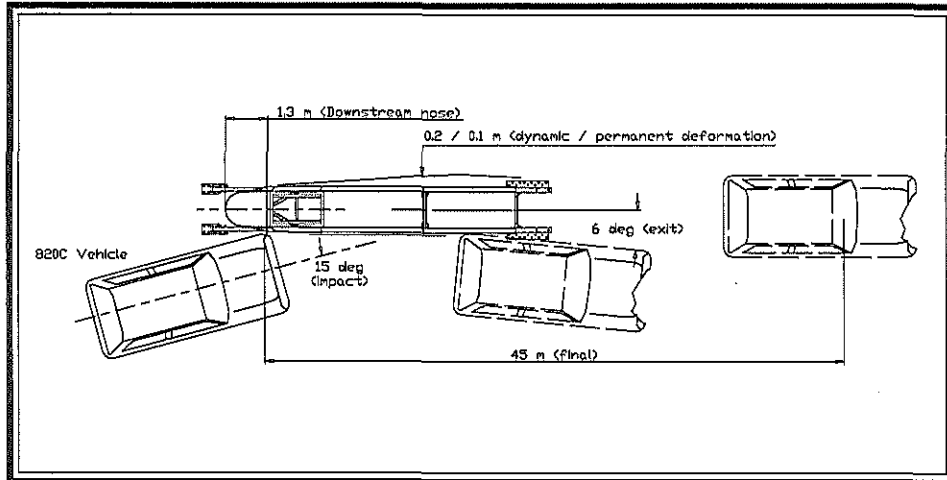
t = 0.384 sec



t = 0.512 sec



t = final



QUEST 70/100 System
Test Article



E-TECH Testing Services, Inc.

QUEST 70/100 Crash Test Results - 36 of 125

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-36
Test No.	01-2174-015
Date	8/17/06
Test Article	
Type	Energy Absorption Systems, Inc.
.....	QUEST™ 70/100 System
Installation Length	5.4 m (effective length)
Material and key elements	AASHTO M180 galvanized steel panels, ASTM A500 Rails, and A36 other
.....	Unreinforced 27.6 MPa concrete, clean and dry with (30) 19 mm x 178 mm
Foundation and Anchoring	ASTM A193 Grade B-7 threaded studs and
.....	MP-3 Anchoring System

Test Vehicle

Type	Production Model
Designation	820C
Model	1989 Ford Festiva
Mass (kg)	
Curb	777
Test inertial	824
Dummy	75
Gross	899

Impact Conditions

Speed (km/h)	71.7
Angle (deg)	15
Impact Severity (kJ)	10.9

Exit conditions

Speed (km/h)	64
Angle (deg - veh. c.g.)	6

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	2.2
y-direction	4.7
Ridedown Acceleration (g's)	
x-direction	-6.3
y-direction	8.5

European Committee for Normalization (CEN) Values

THIV (km/h)	18.7
PHD (g's)	8.6
ASI	0.5

Test Article Deflections (m)

Dynamic	0.2
Permanent	Negligible

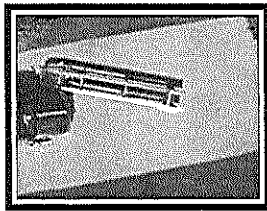
Vehicle Damage (Primary Impact)

Exterior	
VDS	FLQ-1
CDC	11FLEW1
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

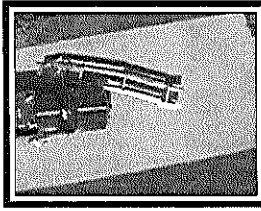
Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	-2.5
Maximum Pitch Angle	-2.3
Maximum Yaw Angle	21.4

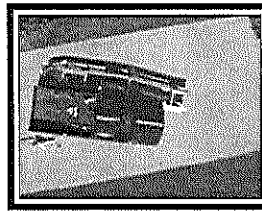
Figure 21. Summary of Results - QUEST NCHRP 350 Test 2-36



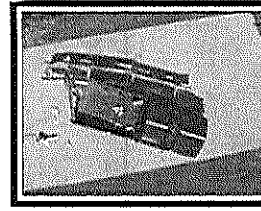
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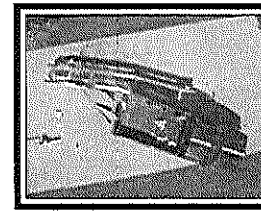
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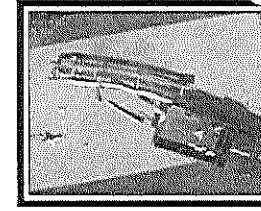
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t = 0.297 sec



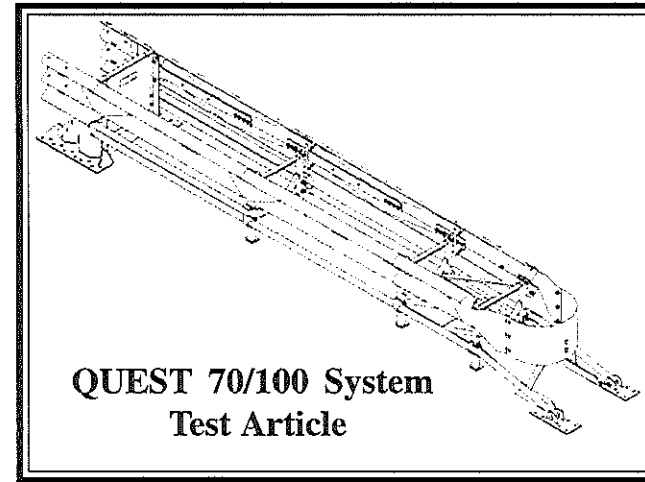
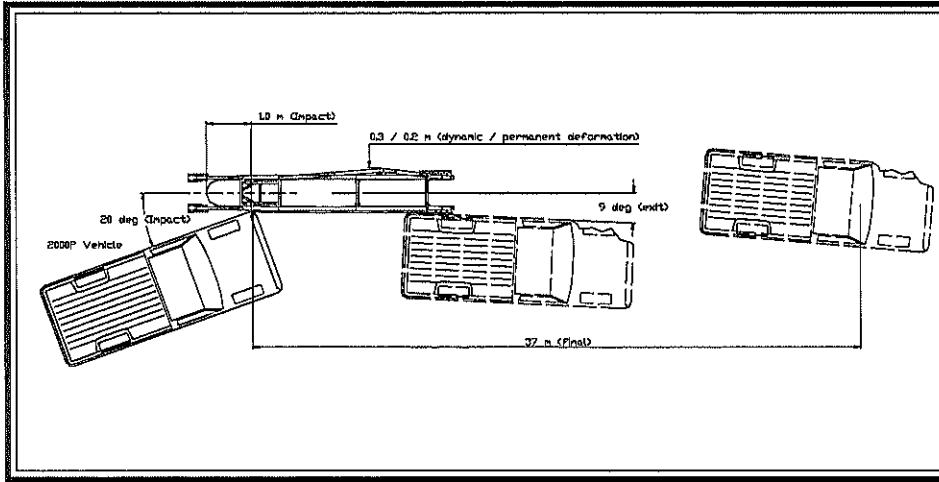
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t = 0.496 sec



E-TECH Testing Services, Inc.



QUEST 70/100 System
Test Article

QUEST 70/100 Crash Test Results - 42 of 125

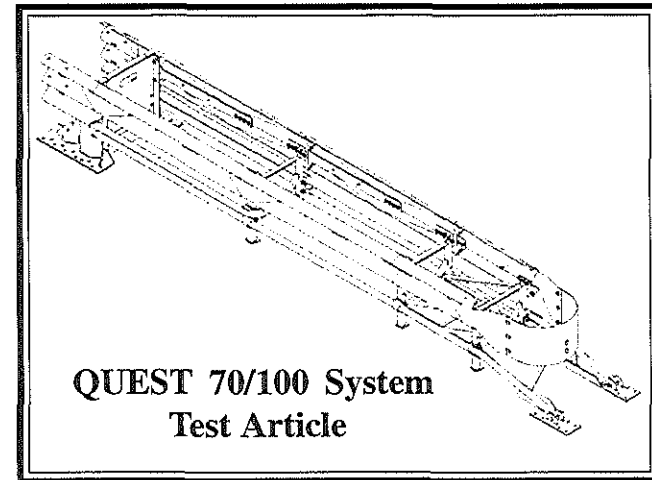
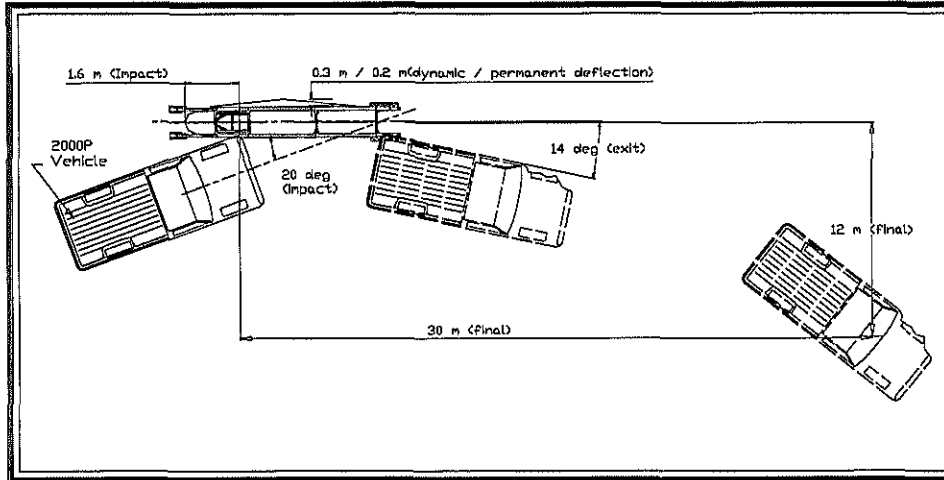
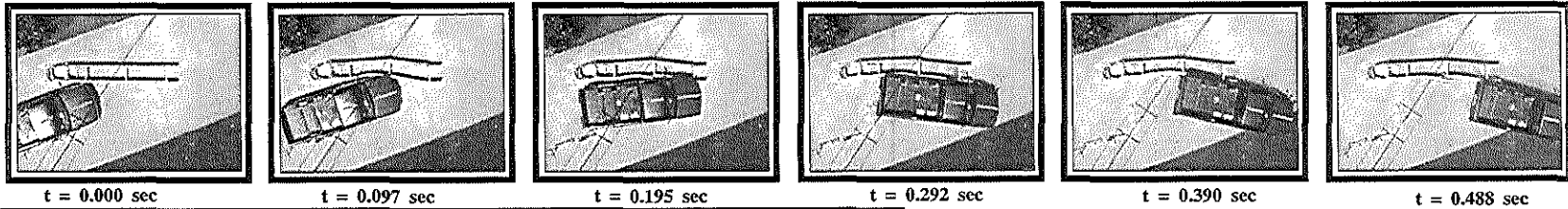
General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-37
Test No.	01-2174-013
Date	7/11/06
Test Article	
Type	Energy Absorption Systems, Inc.
.....	QUEST™ 70/100 System
Installation Length	5.4 m (effective length)
Material and key elements	AASHTO M180 galvanized steel panels, ASTM A500 Rails, and A36 other
Foundation and Anchoring	Unreinforced 27.6 MPa concrete, clean and dry with (30) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1990 Chevrolet C2500
Mass (kg)	
Curb	1975
Test inertial	1992
Dummy	N/A
Gross	1992
Impact Conditions	
Speed (km/h)	71.7
Angle (deg)	20
Impact Severity (kJ)	46.2

Exit conditions

Speed (km/h)	54
Angle (deg - veh. c.g.)	9
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	2.3
y-direction	4.4
Ridedown Acceleration (g's)	
x-direction	-5.6
y-direction	7.0
European Committee for Normalization (CEN) Values	
THIV (km/h)	17.6
PHD (g's)	8.4
ASI	0.5
Test Article Deflections (m)	
Dynamic	0.3
Permanent	0.2
Vehicle Damage (Primary Impact)	
Exterior	
VDS	LFQ-1
CDC	11FLEW1
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	-4.2
Maximum Pitch Angle	-4.6
Maximum Yaw Angle	26.0

Figure 26. Summary of Results - QUEST 70/100 NCHRP 350 Test 2-37



E-TECH Testing Services, Inc.

QUEST 70/100 Crash Test Results - 48 of 125

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-38
Test No.	01-2174-012
Date	7/7/06

Test Article

Type	Energy Absorption Systems, Inc.
.....	QUEST™ 70/100 System
Installation Length	5.4 m (effective length)
Material and key elements	AASHTO M180 galvanized steel panels, ASTM A500 Rails, and A36 other
Foundation and Anchoring	Unreinforced 27.6 MPa concrete, clean and dry with (30) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System

Test Vehicle

Type	Production Model
Designation	2000P
Model	1989 GMC
Mass (kg)	
Curb	1971
Test inertial	2003
Dummy	N/A
Gross	2003

Impact Conditions

Speed (km/h)	70.3
Angle (deg)	20
Impact Severity (kJ)	44.7

Exit conditions

Speed (km/h)	57
Angle (deg - veh. c.g.)	14

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	3.4
y-direction	5.0
Ridedown Acceleration (g's)	
x-direction	-4.1
y-direction	5.8

European Committee for Normalization (CEN) Values

THIV (km/h)	21.0
PHD (g's)	6.4
ASI	0.6

Test Article Deflections (m)

Dynamic	0.3
Permanent	0.2

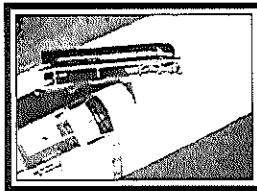
Vehicle Damage (Primary Impact)

Exterior	
VDS	LFQ-1
CDC	11LFEW1
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible

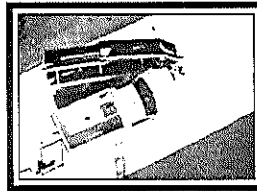
Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	-7.7
Maximum Pitch Angle	-7.3
Maximum Yaw Angle	71.5

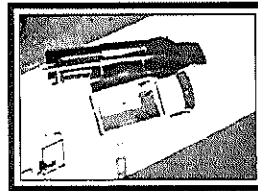
Figure 31. Summary of Results - QUEST 70/100 NCHRP 350 Test 2-38



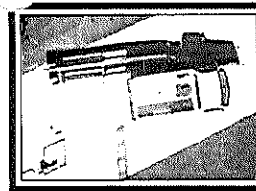
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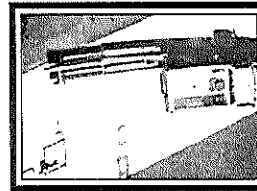
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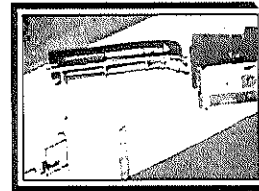
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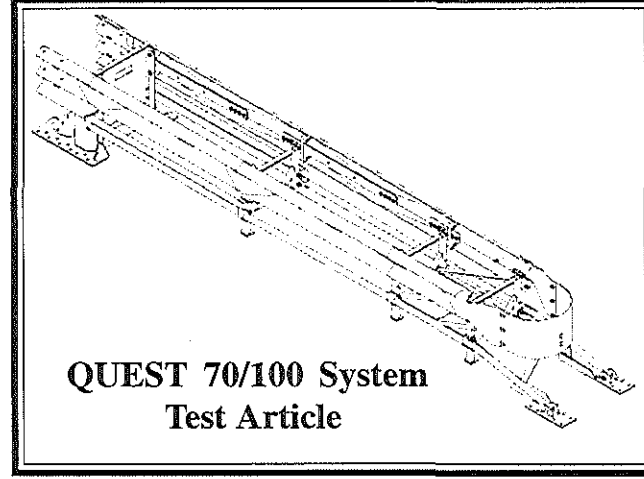
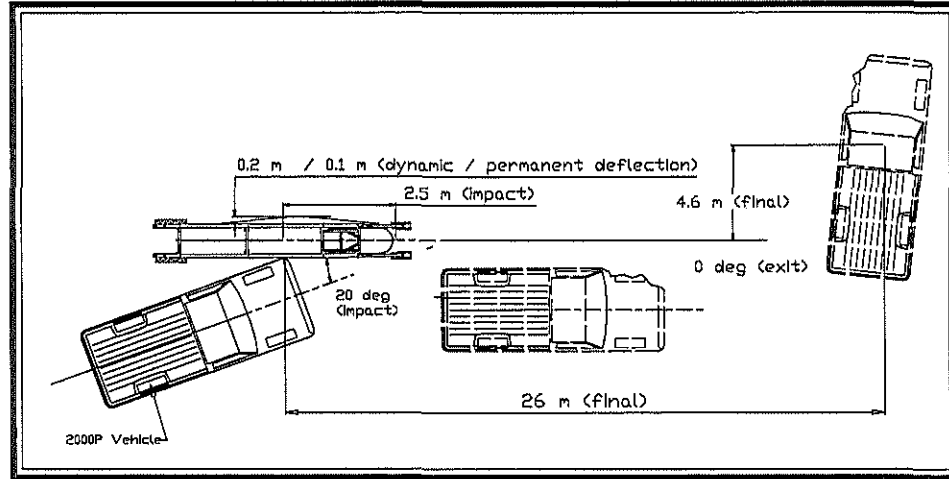
t = 0.294 sec



t = 0.392 sec



t = 0.490



QUEST 70/100 System
Test Article



E-TECH Testing Services, Inc.

QUEST 70/100 Crash Test Results - 54 of 125

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 2-39
Test No.	01-2174-016
Date	8/25/06

Test Article

Type	Energy Absorption Systems, Inc. QUEST™ 70/100 System
Installation Length	5.4 m (effective length)
Material and key elements	AASHTO M180 galvanized steel panels, ASTM A500 Rails, and A36 other
Foundation and Anchoring	150 mm thick asphalt over 200 mm aggregate base with (38) 19 mm x 457 mm ASTM A193 B7 threaded rods MP-3 Asphalt Anchoring System

Test Vehicle

Type	Production Model
Designation	2000P
Model	1989 GMC
Mass (kg)	
Curb	1881
Test inertial	2000
Dummy	N/A
Gross	2000

Impact Conditions

Speed (km/h)	71.0
Angle (deg)	20
Impact Severity (kJ)	45.5

Exit conditions

Speed (km/h)	49
Angle (deg - veh. c.g.)	0

Occupant Risk Values

Impact Velocity (m/s)	
x-direction	4.1
y-direction	4.4
Ridedown Acceleration (g's)	
x-direction	-6.2
y-direction	5.3

European Committee for Normalization (CEN) Values

THIV (km/h)	20.9
PHD (g's)	6.7
ASI	0.6

Test Article Deflections (m)

Dynamic	0.2
Permanent	0.1

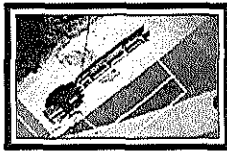
Vehicle Damage (Primary Impact)

Exterior	
VDS	LFQ-1
CDC	11LFEW1
Interior	
VCDI	AS000000
Maximum Deformation (mm)	Negligible

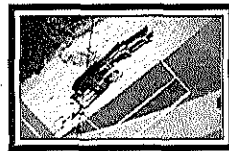
Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle	-12.1
Maximum Pitch Angle	28.0
Maximum Yaw Angle	-72.9

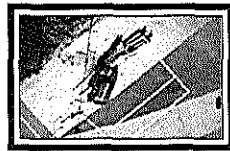
Figure 36. Summary of Results - QUEST 70/100 NCHRP 350 Test 2-39



t = 0.000 sec



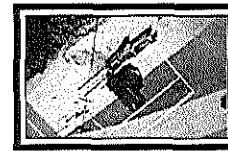
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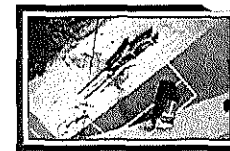
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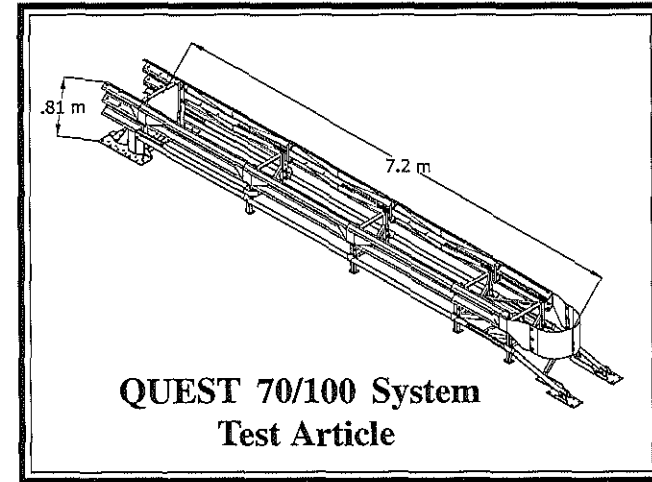
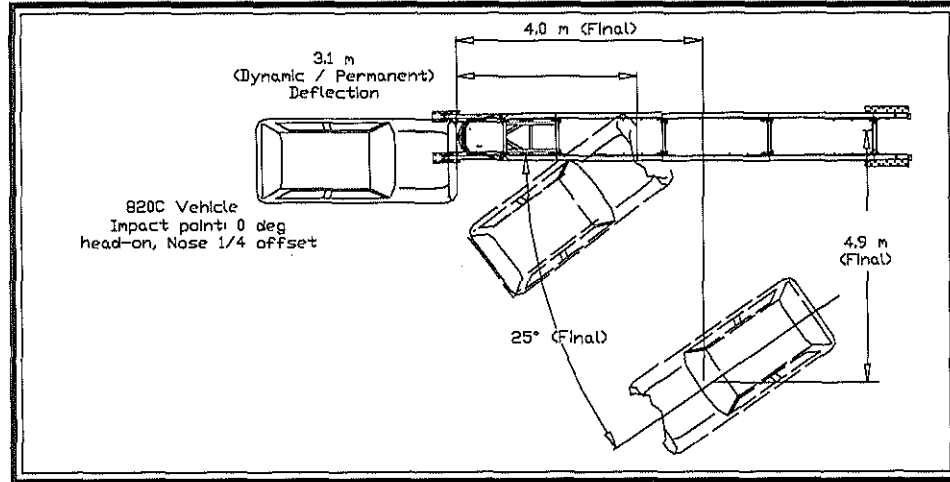
t = 0.288 sec



t = 0.384 sec



t = Final



**QUEST 70/100 System
Test Article**



E-TECH Testing Services, Inc.

QUEST 70/100 Crash Test Results - 12 of 125

General Information

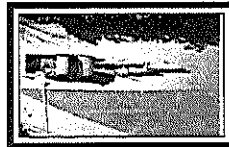
Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-30
Test No.	01-2174-001
Date	9/15/05
Test Article	
Type	Energy Absorption Systems, Inc. QUEST™ 70/100 System
Installation Length	7.2 m (effective length)
Material and key elements	AASHTO M180 galvanized steel panels, ASTM A500 Rails, and A36 other
Foundation and Anchoring	Unreinforced 27.6 MPa concrete, clean and dry with (30) 19 mm x 178 mm ASTMA193 Grade B-7 threaded studs and MP-3 Anchoring System
Test Vehicle	
Type	Production Model
Designation	820C
Model	1992 Ford Festiva
Mass (kg)	
Curb	855
Test inertial	835
Dummy	75
Gross	910
Impact Conditions	
Speed (km/h)	101.8
Angle (deg)	0
Impact Severity (kJ)	333.9

Exit conditions	
Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	11.7
y-direction	1.3
Ridedown Acceleration (g's)	
x-direction	-19.5
y-direction	6.3
European Committee for Normalization (CEN) Values	
THIV (km/h)	42.3
PHD (g's)	19.6
ASI	1.4
Test Article Deflections (m)	
Dynamic	3.1
Permanent	3.1
Vehicle Damage (Primary Impact)	
Exterior	
VDS	FL-4
CDC	12FLEW4
Interior	
VCDI	AS0010000
Maximum Deformation (mm)	40
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	-27
Maximum Pitch Angle	-63.6
Maximum Yaw Angle	-205.1

Figure 1. Summary of Results - QUEST 70/100 NCHRP 350 Test 3-30



t = 0.000 sec



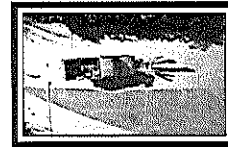
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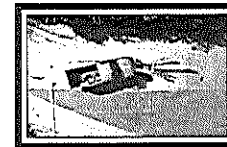
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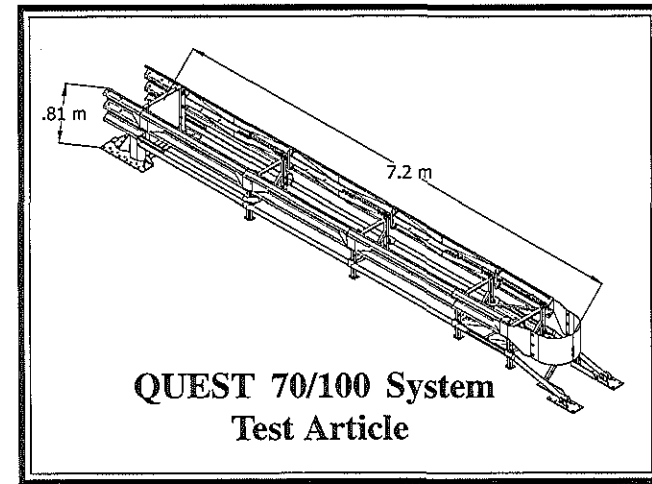
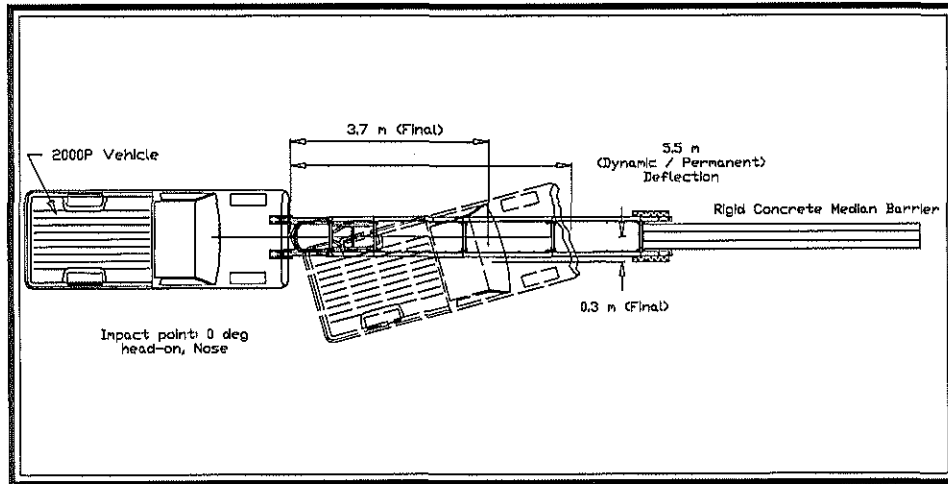
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t = 0.384 sec



t = 0.480 sec



QUEST 70/100 System
Test Article

QUEST 70/100 Crash Test Results - 18 of 125

General Information

Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-31
Test No.	01-2174-005
Date	1/6/06
Test Article	
Type	Energy Absorption Systems, Inc.
.....	QUEST™ 70/100 System
Installation Length	7.2 m (effective length)
Material and key elements	AASHTO M180 galvanized steel panels,
.....	ASTM A500 Rails, and A36 other
Foundation and Anchoring	Unreinforced 27.6 MPa concrete,
.....	clean and dry with (30) 19 mm x 178 mm
.....	ASTM A193 Grade B-7 threaded studs and
.....	MP-3 Anchoring System
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1992 Chevrolet C2500
Mass (kg)	
Curb	1881
Test inertial	2003
Dummy	N/A
Gross	2003
Impact Conditions	
Speed (km/h)	103.2
Angle (deg)	0
Impact Severity (kJ)	823.2

Exit conditions

Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	9.0
y-direction	0.1
Ridedown Acceleration (g's)	
x-direction	-19.1
y-direction	-4.9
European Committee for Normalization (CEN) Values	
THIV (km/h)	32.3
PHD (g's)	19.1
ASI	1.0
Test Article Deflections (m)	
Dynamic	5.5
Permanent	5.5
Vehicle Damage (Primary Impact)	
Exterior	
VDS	FC-2
CDC	12FCEW1
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	-3.2
Maximum Pitch Angle	-8.6
Maximum Yaw Angle	-15.9

Figure 6. Summary of Results - QUEST 70/100 NCHRP 350 Test 3-31



E-TECH Testing Services, Inc.



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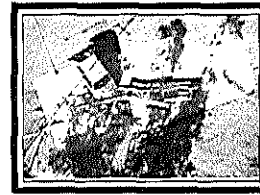
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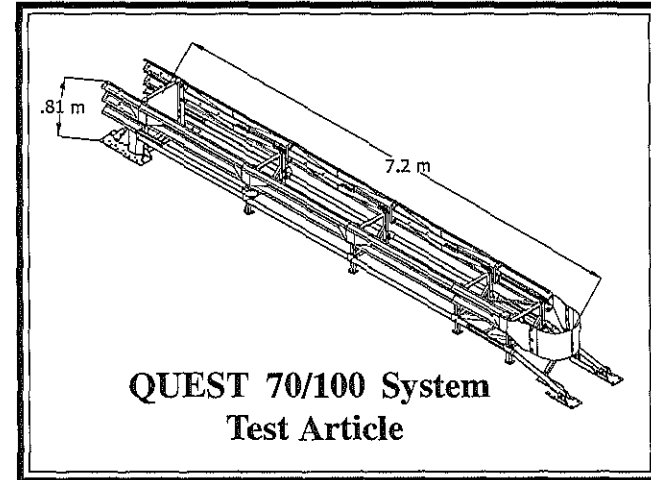
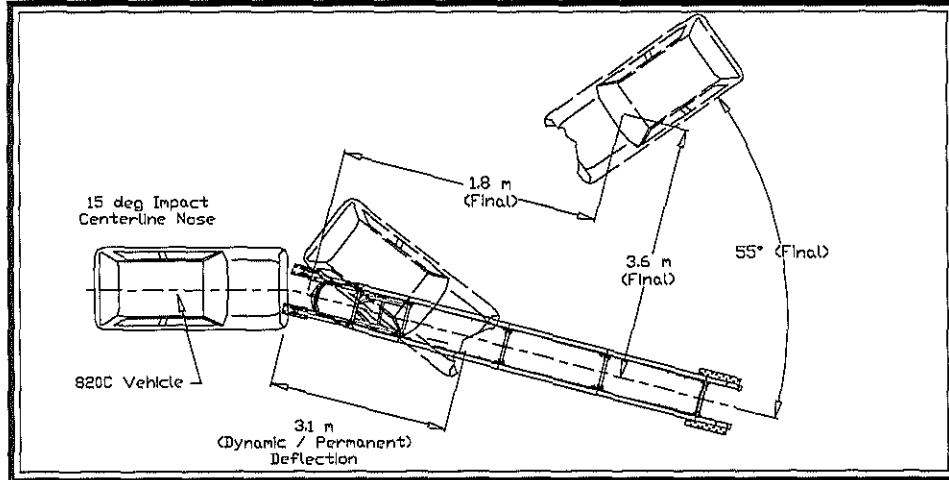
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General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 3-32
 Test No. 01-2174-002
 Date 9/23/05

Test Article

Type Energy Absorption Systems, Inc.
 QUEST™ 70/100 System
 Installation Length 7.2 m (effective length)
 Material and key elements AASHTO M180 galvanized steel panels,
 ASTM A500 Rails, and A36 other
 Foundation and Anchoring Unreinforced 27.6 MPa concrete,
 clean and dry with (30) 19 mm x 178 mm
 ASTM A193 Grade B-7 threaded studs and
 MP-3 Anchoring System

Test Vehicle

Type Production Model
 Designation 820C
 Model 1990 Ford Festiva
 Mass (kg)
 Curb 814
 Test inertial 827
 Dummy 75
 Gross 902

Impact Conditions

Speed (km/h) 101.1
 Angle (deg) 15
 Impact Severity (kJ) 325.8

Exit conditions

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

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 11.9
 y-direction 0.7
 Ridedown Acceleration (g's)
 x-direction -18.2
 y-direction -3.6

European Committee for Normalization (CEN) Values

THIV (km/h) 43.3
 PHD (g's) 18.3
 ASI 1.4

Test Article Deflections (m)

Dynamic 3.1
 Permanent 3.1

Vehicle Damage (Primary Impact)

Exterior
 VDS FC-4
 CDC 12FCEW4
 Interior
 VCDI AS0000000
 Maximum Deformation (mm) 10

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle 40.5
 Maximum Pitch Angle -40.3
 Maximum Yaw Angle 125.2

QUEST 70/100 Crash Test Results - 24 of 125

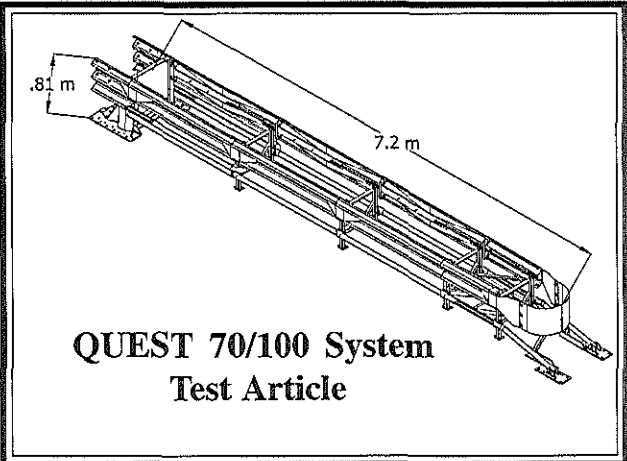
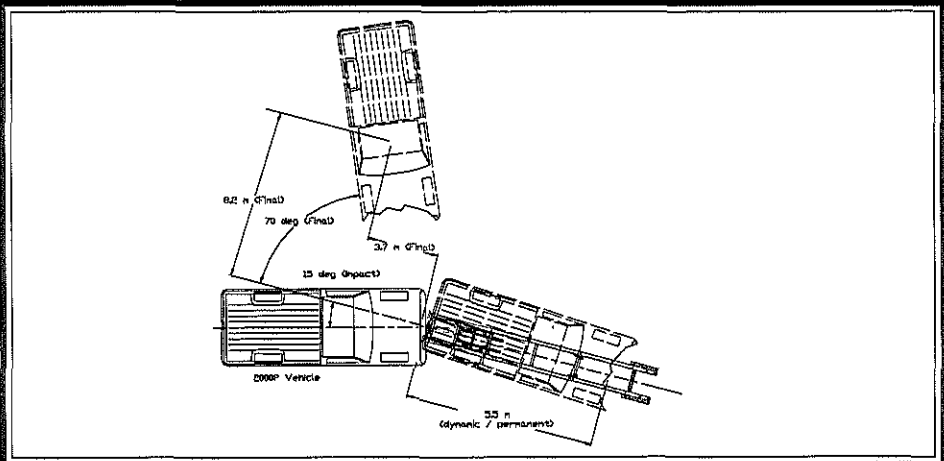
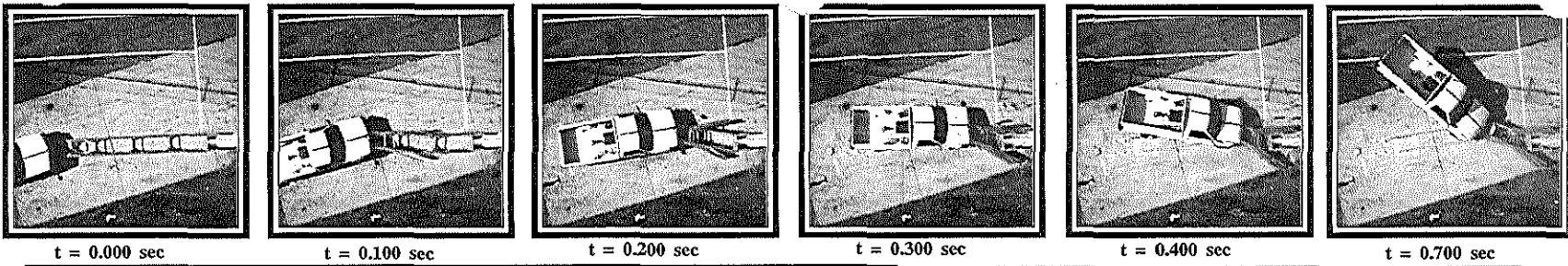


E-TECH Testing Services, Inc.

Figure 11. Summary of Results - QUEST 70/100 NCHRP 350 Test 3-32



E-TECH Testing Services, Inc.



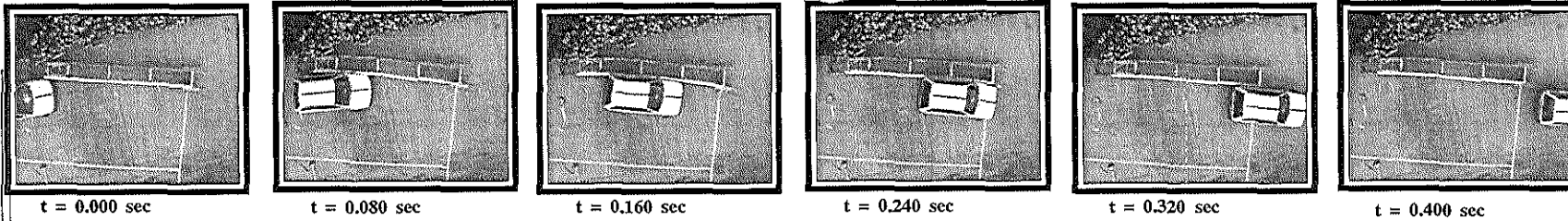
**QUEST 70/100 System
Test Article**

QUEST 70/100 Crash Test Results - 30 of 125

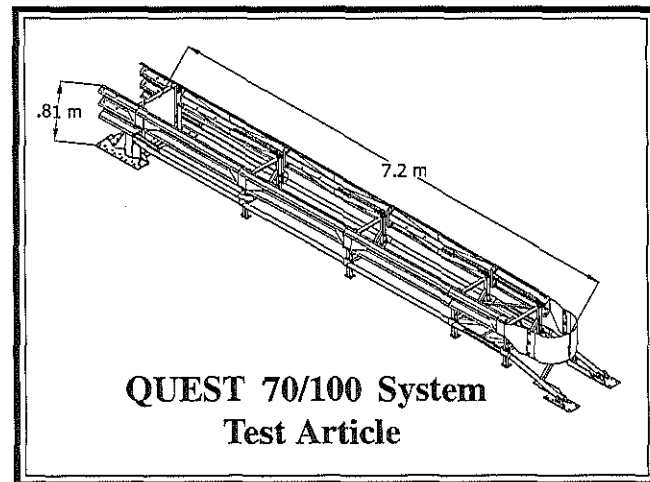
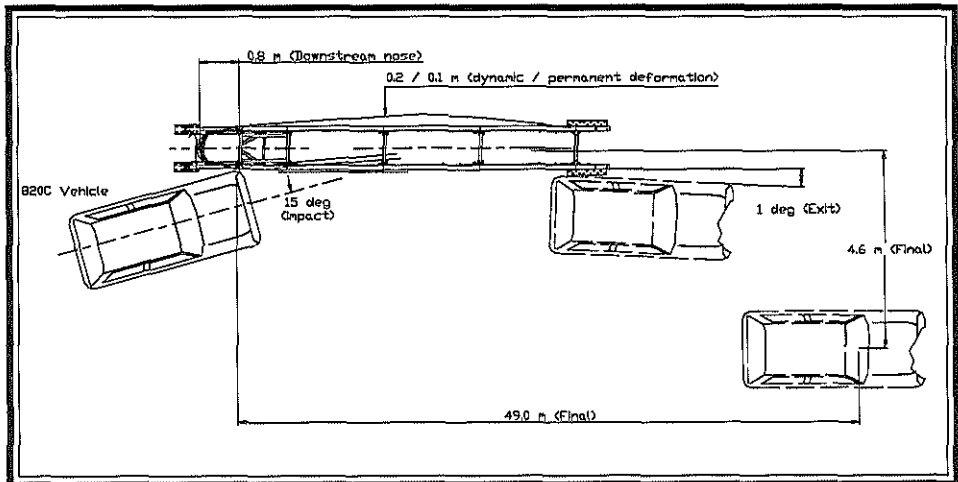
General Information	
Test Agency	E-TECH Testing Services, Inc.
Test Designation	NCHRP 350 Test 3-33
Test No.	01-2174-006
Date	2/22/06
Test Article	
Type	Energy Absorption Systems, Inc. QUEST™ 70/100 System
Installation Length	7.2 m (effective length)
Material and key elements	AASHTO M180 galvanized steel panels, ASTM A500 Rails, and A36 other
Foundation and Anchoring	Unreinforced 27.6 MPa concrete, clean and dry with (30) 19 mm x 178 mm ASTM A193 Grade B-7 threaded studs and MP-3 Anchoring System
Test Vehicle	
Type	Production Model
Designation	2000P
Model	1988 Chevrolet C2500
Mass (kg)	
Curb	1956
Test inertial	2003
Dummy	N/A
Gross	2003
Impact Conditions	
Speed (km/h)	101.8
Angle (deg)	15
Impact Severity (kJ)	816.3

Exit conditions	
Speed (km/h)	N/A
Angle (deg - veh. c.g.)	N/A
Occupant Risk Values	
Impact Velocity (m/s)	
x-direction	9.0
y-direction	0.7
Ridedown Acceleration (g's)	
x-direction	-17.1
y-direction	5.2
European Committee for Normalization (CEN) Values	
THIV (km/h)	32.6
PHD (g's)	17.1
ASI	1.0
Test Article Deflections (m)	
Dynamic	5.5
Permanent	5.5
Vehicle Damage (Primary Impact)	
Exterior	
VDS	FC-3
CDC	12FCEW3
Interior	
VCDI	AS0000000
Maximum Deformation (mm)	Negligible
Post-Impact Vehicular Behavior (deg - rate gyro)	
Maximum Roll Angle	22.8
Maximum Pitch Angle	-27.0
Maximum Yaw Angle	82.1

Figure 16. Summary of Results - QUEST 70/100 NCHRP 350 Test 3-33



E-TECH Testing Services, Inc.

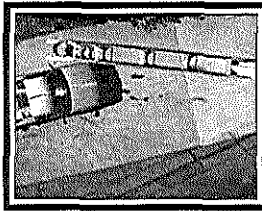


**QUEST 70/100 System
Test Article**

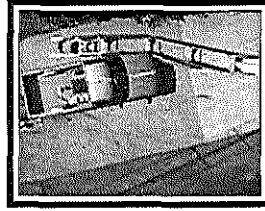
QUEST 70/100 Crash Test Results - 36 of 125

General Information		Exit conditions	
Test Agency	E-TECH Testing Services, Inc.	Speed (km/h)	85
Test Designation	NCHRP 350 Test 3-36	Angle (deg - veh. c.g.)	1
Test No.	01-2174-009	Occupant Risk Values	
Date	6/7/06	Impact Velocity (m/s)	
Test Article		x-direction	1.7
Type	Energy Absorption Systems, Inc.	y-direction	5.1
	QUEST™ 70/100 System	Ridedown Acceleration (g's)	
Installation Length	7.2 m (effective length)	x-direction	-8.4
Material and key elements	AASHTO M180 galvanized steel panels,	y-direction	10.9
	ASTM A500 Rails, and A36 other	European Committee for Normalization (CEN) Values	
Foundation and Anchoring	Unreinforced 27.6 MPa concrete,	THIV (km/h)	19.5
	clean and dry with (30) 19 mm x 178 mm	PHD (g's)	12.0
	ASTM A193 Grade B-7 threaded studs and	ASI	0.8
	MP-3 Anchoring System	Test Article Deflections (m)	
Test Vehicle		Dynamic	0.2
Type	Production Model	Permanent	0.1
Designation	820C	Vehicle Damage (Primary Impact)	
Model	1989 Ford Festiva	Exterior	
Mass (kg)		VDS	FL-2
Curb	809	CDC	11FLEW2
Test inertial	818	Interior	
Dummy	75	VCDI	AS0000000
Gross	893	Maximum Deformation (mm)	Negligible
Impact Conditions		Post-Impact Vehicular Behavior (deg - rate gyro)	
Speed (km/h)	99.0	Maximum Roll Angle	6.7
Angle (deg)	15	Maximum Pitch Angle	3.5
Impact Severity (kJ)	20.7	Maximum Yaw Angle	20.7

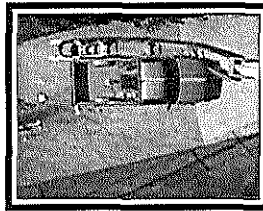
Figure 21. Summary of Results - QUEST NCHRP 350 Test 3-36



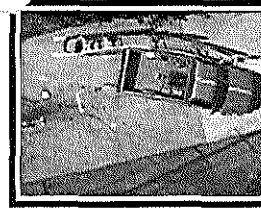
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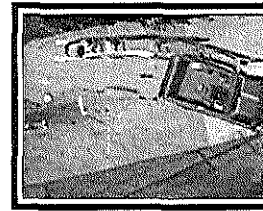
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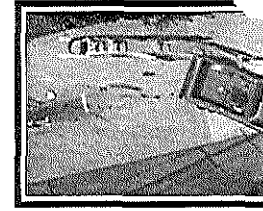
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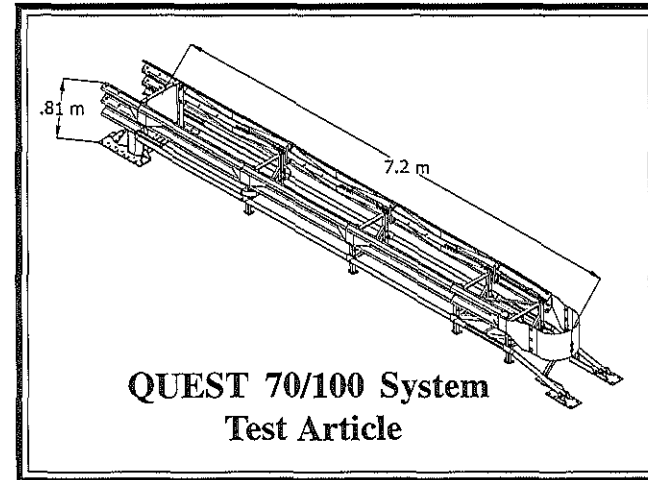
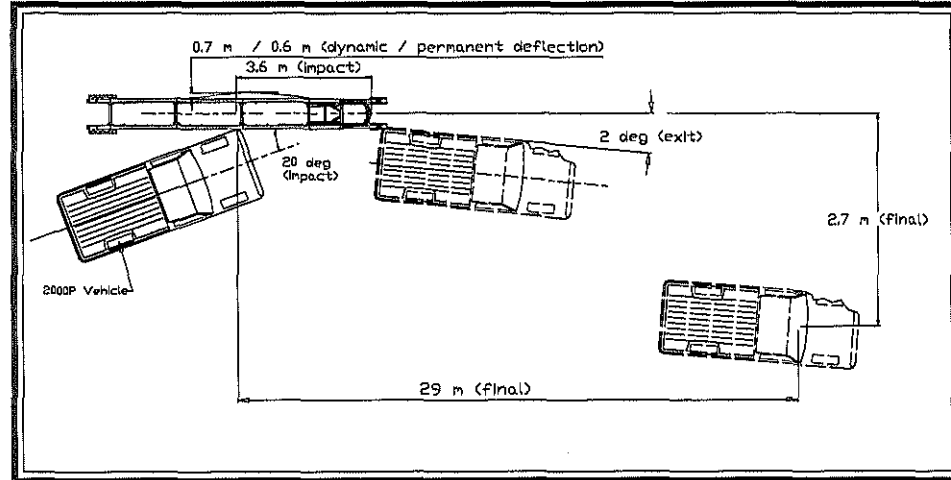
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**QUEST 70/100 System
Test Article**

General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 3-37
 Test No. 01-2174-007
 Date 3/9/06

Test Article

Type Energy Absorption Systems, Inc.
 QUEST™ 70/100 System
 Installation Length 7.2 m (effective length)
 Material and key elements AASHTO M180 galvanized steel panels,
 ASTM A500 Rails, and A36 other
 Foundation and Anchoring Unreinforced 27.6 MPa concrete,
 clean and dry with (30) 19 mm x 178 mm
 ASTM A193 Grade B-7 threaded studs and
 MP-3 Anchoring System

Test Vehicle

Type Production Model
 Designation 2000P
 Model 1994 GMC
 Mass (kg)
 Curb 1840
 Test inertial 1983
 Dummy N/A
 Gross 1983

Impact Conditions

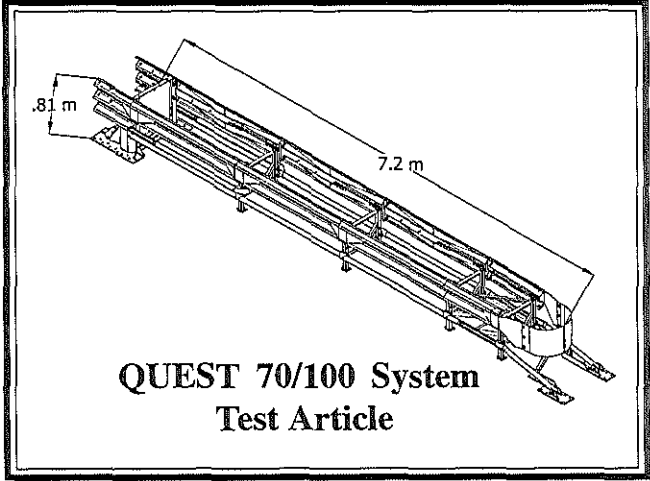
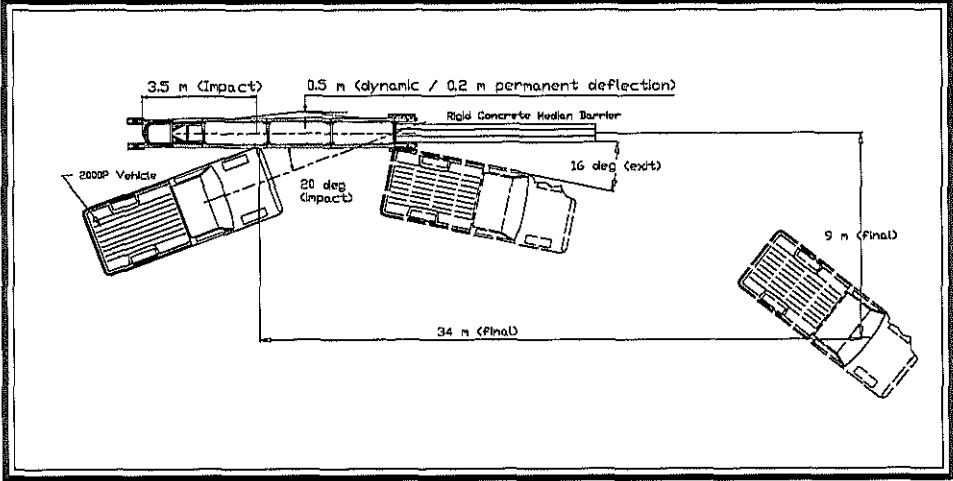
Speed (km/h) 99.7
 Angle (deg) 20
 Impact Severity (kJ) 88.9

Exit conditions

Speed (km/h) 71
 Angle (deg - veh. c.g.) 12
Occupant Risk Values
 Impact Velocity (m/s)
 x-direction 2.8
 y-direction 5.2
 Ridedown Acceleration (g's)
 x-direction -13.7
 y-direction 14.1
European Committee for Normalization (CEN) Values
 THIV (km/h) 21.1
 PHD (g's) 16.6
 ASI N/A
Test Article Deflections (m)
 Dynamic 0.7
 Permanent 0.6
Vehicle Damage (Primary Impact)
 Exterior
 VDS FL-4
 CDC 11FLEW4
 Interior
 VCDI AS0000000
 Maximum Deformation (mm) Negligible
Post-Impact Vehicular Behavior (deg - rate gyro)
 Maximum Roll Angle -11.2
 Maximum Pitch Angle -14.9
 Maximum Yaw Angle 109.5



Figure 26. Summary of Results - QUEST 70/100 NCHRP 350 Test 3-37



E-TECH Testing Services, Inc.

QUEST 70/100 Crash Test Results - 48 of 125

General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 3-38
 Test No. 01-2174-004
 Date 12/13/05

Test Article

Type Energy Absorption Systems, Inc.
 QUEST™ 70/100 System
 Installation Length 7.2 m (effective length)
 Material and key elements AASHTO M180 galvanized steel panels,
 ASTM A500 Rails, and A36 other
 Foundation and Anchoring Unreinforced 27.6 MPa concrete,
 clean and dry with (30) 19 mm x 178 mm
 ASTM A193 Grade B-7 threaded studs and
 MP-3 Anchoring System

Test Vehicle

Type Production Model
 Designation 2000P
 Model 1988 Chevrolet C2500
 Mass (kg)
 Curb 1927
 Test inertial 1972
 Dummy N/A
 Gross 1972

Impact Conditions

Speed (km/h) 99.0
 Angle (deg) 20
 Impact Severity (kJ) 87.2

Exit conditions

Speed (km/h) 71
 Angle (deg - veh. c.g.) 16

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 6.6
 y-direction 6.3
 Ridedown Acceleration (g's)
 x-direction -8.9
 y-direction 14.1

European Committee for Normalization (CEN) Values

THIV (km/h) 30.6
 PHD (g's) 14.1
 ASI 1.0

Test Article Deflections (m)

Dynamic 0.5
 Permanent 0.2

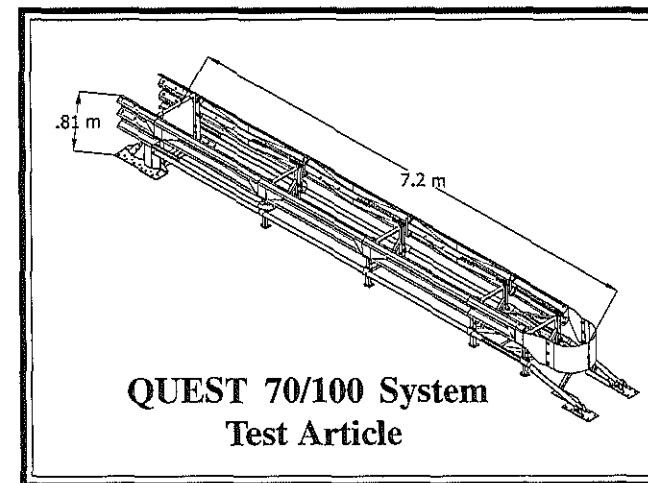
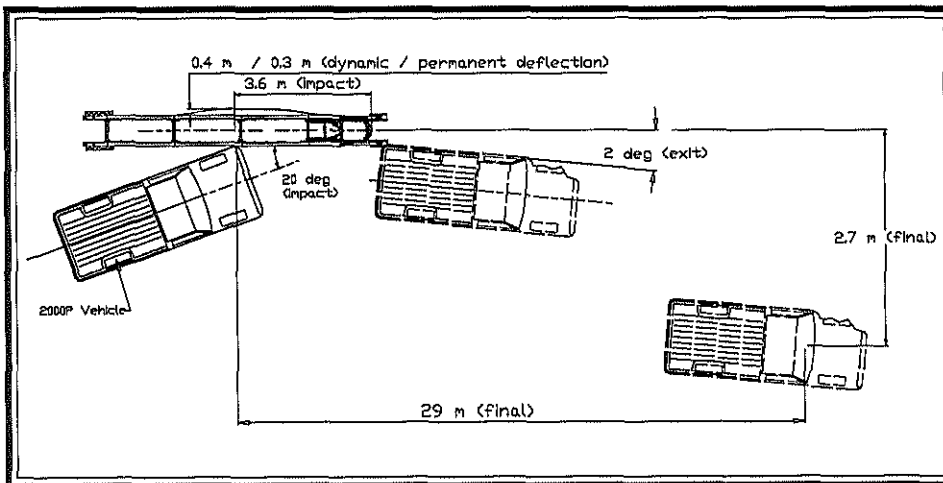
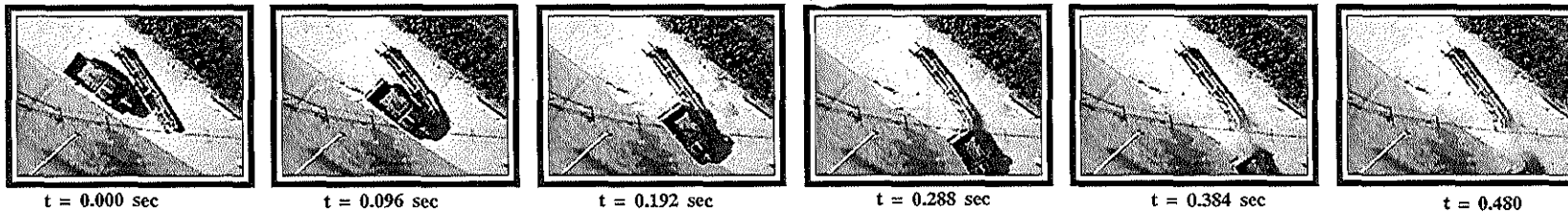
Vehicle Damage (Primary Impact)

Exterior
 VDS LFQ-5
 CDC 11LFEW3
 Interior
 VCDI LF0010000
 Maximum Deformation (mm) 70.0

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle -29.1
 Maximum Pitch Angle -13.4
 Maximum Yaw Angle 48.6

Figure 31. Summary of Results - QUEST 70/100 NCHRP 350 Test 3-38



E-TECH Testing Services, Inc.

QUEST 70/100 Crush Test Results - 54 of 125

General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 3-39
 Test No. 01-2174-003
 Date 11/16/05

Test Article

Type Energy Absorption Systems, Inc.
 QUEST™ 70/100 System
 Installation Length 7.2 m (effective length)
 Material and key elements AASHTO M180 galvanized steel panels,
 ASTM A500 Rails, and A36 other
 Foundation and Anchoring 150 mm thick asphalt over 200 mm
 aggregate base with (38) 19 mm x 457 mm
 ASTM A193 B7 threaded rods
 MP-3 Asphalt Anchoring System

Test Vehicle

Type Production Model
 Designation 2000P
 Model 1988 Chevrolet C2500
 Mass (kg)
 Curb 1913
 Test inertial 2009
 Dummy N/A
 Gross 1913

Impact Conditions

Speed (km/h) 100.4
 Angle (deg) 20
 Impact Severity (kJ) 91.3

Exit conditions

Speed (km/h) 72
 Angle (deg - veh. c.g.) 2

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 6.4
 y-direction 6.4
 Ridedown Acceleration (g's)
 x-direction -7.5
 y-direction -8.7

European Committee for Normalization (CEN) Values

THIV (km/h) 33.5
 PHD (g's) 13.9
 ASI 1.6

Test Article Deflections (m)

Dynamic 0.4
 Permanent 0.3

Vehicle Damage (Primary Impact)

Exterior
 VDS LFQ-5
 CDC 11LFEW2
 Interior
 VCDI LF0010000
 Maximum Deformation (mm) 75

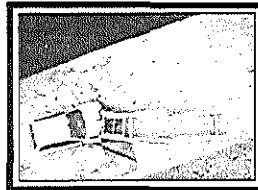
Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle -15.5
 Maximum Pitch Angle -7.9
 Maximum Yaw Angle 30.3

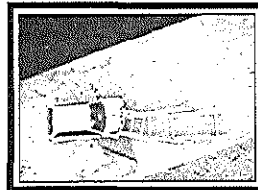
Figure 36. Summary of Results - QUEST 70/100 NCHRP 350 Test 3-39



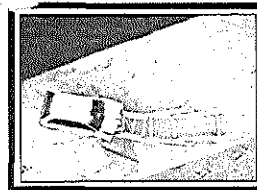
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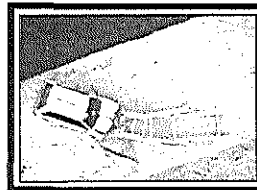
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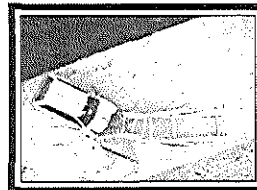
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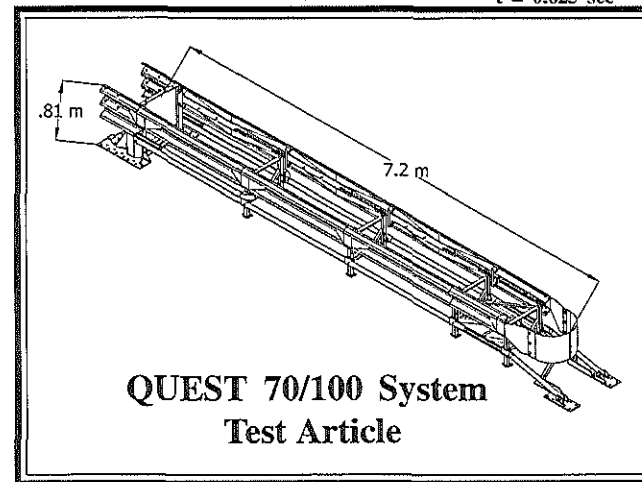
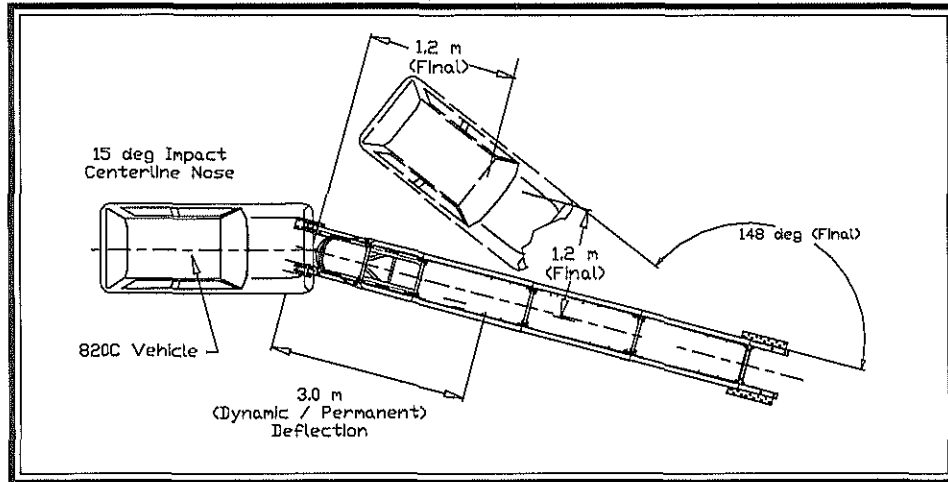
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t = 0.625 sec



**QUEST 70/100 System
Test Article**

General Information

Test Agency E-TECH Testing Services, Inc.
 Test Designation NCHRP 350 Test 3-32
 Test No. 01-5500-012
 Date 9/23/05

Test Article

Type Energy Absorption Systems, Inc.
 915 mm Wide QUEST™ 70/100 System
 Installation Length 7.2 m (effective length)
 Material and key elements AASHTO M180 galvanized steel panels,
 ASTM A500 Rails, and A36 other
 Foundation and Anchoring Unreinforced 27.6 MPa concrete,
 clean and dry with (30) 19 mm x 178 mm
 ASTM A193 Grade B-7 threaded studs and
 MP-3 Anchoring System

Test Vehicle

Type Production Model
 Designation 820C
 Model 1988 Ford Festiva
 Mass (kg)
 Curb 792
 Test inertial 810
 Dummy 75
 Gross 885

Impact Conditions

Speed (km/h) 101.1
 Angle (deg) 15
 Impact Severity (kJ) 319.1

Exit conditions

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

Occupant Risk Values

Impact Velocity (m/s)
 x-direction 11.7
 y-direction 0.6
 Ridedown Acceleration (g's)
 x-direction -19.0
 y-direction -7.1

European Committee for Normalization (CEN) Values

THIV (km/h) 42.2
 PHD (g's) 19.3
 ASI 1.4

Test Article Deflections (m)

Dynamic 3.0
 Permanent 3.0

Vehicle Damage (Primary Impact)

Exterior
 VDS FC-4
 CDC 12FCEW4
 Interior
 VCDI AS0000000
 Maximum Deformation (mm) Negligible

Post-Impact Vehicular Behavior (deg - rate gyro)

Maximum Roll Angle 17.4
 Maximum Pitch Angle -15.6
 Maximum Yaw Angle 63.2

Summary of Results - 915 mm Wide QUEST 70/100 System NCHRP 350 Test 3-32

The results of this report relate only to the 915 mm wide QUEST 70/100 configuration tested. This report may not be reproduced except in full, without the prior written approval of E-TECH Testing Services, Inc.
 Prepared by: John F. LaTurner, P.E. - Manager, Report 298 - Issued 09/05

