

165197



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Traffic Safety
Administration**

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Subject: Submittal of "A Comparative Evaluation of the Hybrid II and Hybrid III Child Dummy Families" to Docket NHTSA-02-11707 Date **APR 12 2002**

Raymond P. Owings, Ph.D.

From: Associate Administrator for
Research and Development

Reply to
Attn of

To: The Docket
THRU: *Jacqueline Glassman*
- Chief Counsel

A study comparing the performance between the Hybrid II and the Hybrid III child dummy families is provided. The Hybrid II and Hybrid III 6-year-old, 3-year-old, and infant dummies were evaluated with a series of sled tests using the FMVSS No. 213 pulse and buck. Head acceleration, chest acceleration, and excursion results were analyzed. A summary of this evaluation is attached for inclusion into the above public docket.

Attachment

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**A COMPARATIVE EVALUATION OF THE HYBRID II AND HYBRID III CHILD
DUMMY FAMILIES**

NHTSA TECHNICAL REPORT

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December 2001

I. Introduction

This report compares the performance of the Hybrid II and Hybrid III child dummy families, as well as the 9-month-old infant and a 12 month-old infant (CRABI-12). Currently, the Hybrid II dummies, consisting of a Hybrid II six-year-old child (HII-6C) and a Hybrid II three-year-old child (HII-3C), are specified for use with FMVSS 213. However, the Hybrid II dummies have limited instrumentation and the newly developed Hybrid III child dummies and CRABI-12 appear ready for use in evaluating child restraints. The Hybrid III child dummies include a new six-year-old child (HIII-6C) and a three-year-old-child (HIII-3C).

The Hybrid III dummies and CRABI-12 contain an advanced neck design with improved biofidelity compared to the Hybrid II dummies, and also provide greater instrumentation capabilities, including load cells at the upper neck, lower neck, and lumbar region. The HIII-3C and HIII-6C also contain a potentiometer to measure chest deflection. Additional load cell and accelerometer instrumentation is possible for the Hybrid III child dummies and varies according to dummy size. A detailed listing of the available instrumentation for the Hybrid III child dummies and CRABI-12 can be found in the respective Procedures for Assembly, Disassembly, and Inspection (PADI) documents (see 49 CFR Part 572).

Sled tests using the FMVSS 213 sled buck and pulse were conducted to compare the performance of the old and new dummies. The response of the Hybrid II and Hybrid III dummies and 9-month-old infant and CRABI-12 is evaluated to determine the suitability of integrating the Hybrid III child dummies and CRABI-12 into FMVSS 213.

11. Methods of Analysis

Sled tests were conducted using the FMVSS 213 pulse and buck to evaluate the infant, Hybrid II and Hybrid III child dummies. Results from previous compliance sled tests using the 9-month-old and Hybrid II child dummies were also analyzed and used in this study. The performance of the 9-month-old, CRABI-12, Hybrid II three-year-old and six-year-old child dummies, and the Hybrid III three-year-old and six-year-old child dummies was evaluated. The dummies were seated in various child restraint systems (CRSs) and safety belt configurations. For direct comparison, at least one of each Hybrid II and Hybrid III three-year-old and six-year-old dummy was evaluated in each CRS. The CRABI-12 was tested in both the forward-facing and rear-facing configurations. The head and knee excursion, HIC, and chest acceleration values were compared between the infant dummies and the Hybrid II and Hybrid III dummies for each age group.

111. Results

Tables 1, 2, and 3 below summarize the results of the sled tests for the six-year-old, three-year-old, and infant dummies, respectively. The type of CRS employed, safety belt configuration, and dummy orientation are listed for each test. Typical FMVSS 213 pulse curves from each test facility and individual data channel time history plots are shown in Appendix A.

Table 1. Sled test results for Hybrid II and Hybrid III six-year-old child dummies

Test No.	Test Facility	Peak G	Test Speed (mph)	Dummy Type	Restraint Configuration	Orientation	Head Excur. (in)	Knee Excur. (in)	HIC			3 ms Chest Clip (G)
									15 ms	36 ms	un-windowed	
18514	VER	22.2	28.7	Hybrid II 6yo	Cosco Grand Explorer w/ lap/shoulder	Fwd-facing	16.0	23.0	-----	-----	347	38.6
TRC487	VRTC	23.3	29.1	Hybrid II 6yo	Cosco Grand Explorer w/ lap/shoulder	Fwd-facing	18.1	24.1	179	379	454	65.8
TRC435	VRTC	24.9	29.9	Hybrid III 6yo	Cosco Grand Explorer w/ lap/shoulder	Fwd-facing	19.9	23.0	716	1053	1141	54.0
18494	VER	22.2	28.6	Hybrid II 6yo	Century Breverra Classic w/ lap/shoulder	Fwd-facing	17.0	25.0	-----	-----	326	32.0
TRC486	VRTC	23.1	29.1	Hybrid II 6yo	Century Breverra Classic w/ lap/shoulder	Fwd-facing	18.9	25.4	192	417	530	44.6
TRC442	VRTC	23.2	28.9	Hybrid III 6yo	Century Breverra Classic w/ lap/shoulder	Fwd-facing	21.0	24.4	470	826	974	54.3
TRC443	VRTC	23.3	30.0	Hybrid III 6yo	Century Breverra Classic w/ lap/shoulder	Fwd-facing	21.5	21.7	484	688	825	54.4


Note:  Indicates response exceeded injury criteria

Table 2. Sled test results :

Test No.	Test Facility	Peak G	Test Speed (mph)	Dummy Type	Restraint Configuration	Orientation	Head Excur. (in)	Knee Excur. (in)	HIC			3 ms Chest Clip (G)
									15 ms	36 ms	un-windowed	
TRC484	VRTC	23.2	29.2	Hybrid II 3yo	Cosco Touriva w/ lap belt ONLY	Fwd-facing	24.4	25.4	226	372	385	41.9
00696	PAX	23.7	-----	Hybrid II 3yo	Cosco Touriva w/ lap belt ONLY	Fwd-facing	28.0	32.0	-----	-----	479	37.2
18660	VER	22.6	28.8	Hybrid II 3yo	Cosco Touriva w/ lap belt ONLY	Fwd-facing	28.0	32.0	-----	-----	424	35.6
TRC383	VRTC	25.0	28.6	Hybrid III 3yo	Cosco Touriva w/ lap belt ONLY	Fwd-facing	27.0	31.7	375	671	733	43.4
TRC425	VRTC	25.0	28.7	Hybrid III 3yo	Cosco Touriva w/ lap/shoulder belt	Fwd-facing	24.4	31.3	489	738	738	53.8
30697	PAX	23.7	-----	Hybrid II 3yo	Cosco Touriva w/ lap belt/top tether	Fwd-facing	23.0	28.0	-----	-----	387	46.4
18661	VER	22.5	28.7	Hybrid II 3yo	Cosco Touriva w/ lap belt/top tether	Fwd-facing	23.0	32.0	-----	-----	396	46.3
TRC440	VRTC	23.3	30.3	Hybrid III 3yo	Cosco Touriva w/ lap belt/top tether	Fwd-facing	21.7	26.8	168	303	323	37.5
TRC441	VRTC	23.2	29.1	Hybrid III 3yo	Cosco Touriva w/ lap belt/top tether	Fwd-facing	20.1	25.4	194	362	369	42.6
TRC440	VRTC	23.3	30.3	Hybrid II 3yo	Cosco Triad w/ LATCH	Fwd-facing	19.6	23.7	118	218	281	38.9
TRC441	VRTC	23.2	29.1	Hybrid II 3yo	Cosco Triad w/ LATCH	Fwd-facing	22.3	24.9	142	257	336	44.8
TRC383	VRTC	25.0	28.6	Hybrid III 3yo	Cosco Triad w/ LATCH	Fwd-facing	20.6	26.8	174	292	310	47.6
TRC425	VRTC	25.0	28.7	Hybrid III 3yo	Cosco Triad w/ LATCH	Fwd-facing	19.1	23.8	347	518	518	48.1
18530	VER	22.4	28.7	Hybrid II 3yo	Century Breverra Classic - 5pt/tether	Fwd-facing	24.0	29.0	-----	-----	392	41.4
TRC485	VRTC	23.3	29.2	Hybrid II 3yo	Century Breverra Classic - 5pt/tether	Fwd-facing	23.0	29.3	388	501	501	48.8
TRC442	VRTC	23.2	28.9	Hybrid III 3yo	Century Breverra Classic - 5pt/tether	Fwd-facing	24.0	28.3	317	452	452	48.3
TRC443	VRTC	23.3	30.0	Hybrid III 3yo	Century Breverra Classic - 5pt/tether	Fwd-facing	22.3	26.7	288	439	439	44.7

Table 3. Sled test results for infant dummies

Test No.	Test Facility	Peak G	Test Speed (mph)	Dummy Type	Restraint Configuration	Orientation	Head Excur. (in)	Knee Excur. (in)	HIC			3 ms Chest Clip (G)
									15 ms	36 ms	un-windowed	
TRC484 00574	VRTC	23.2	29.2	CRABI-12 mo.	Evenflo On My Way	Rear-facing	-----	-----	226	340	448	43.5
	PAX	23.7	-----	9 mos	Evenflo On My Way	Rear-facing	-----	-----	-----	-----	-----	-----
TRC485 00580		23.3	29.2	CRABI-12 mo.	Century SmartFit	Rear-facing	-----	-----	270	429	614	39.6
		23.7	-----	9 mos	Century SmartFit	Rear-facing	-----	-----	-----	-----	-----	-----
TRC486	VRTC	23.1	29.1	CRABI-12 mo.	Cosco Touriva w/ top tether	Fwd-facing	18.6	20.9	208	322	322	55.4
TRC487	VRTC	23.3	29.1	CRABI-12 mo.	Cosco Touriva w/ top tether	Fwd-facing	18.6	20.1	235	355	356	57.4
18674	VER	23.8	-----	9 mos	Cosco Touriva w/ top tether	Fwd-facing	21.0	23.0	-----	-----	-----	-----
		22.4	-----	9 mos	Cosco Touriva w/ top tether	Fwd-facing	21.0	N/A	-----	-----	-----	-----
<i>Injury Criteria</i>							28	36	390	1000	1000	50

Note:  Indicates response exceeded injury criteria

IV. Discussion

A. Six-Year-Old Child

Head & Knee Excursion

The results presented in Table 1 show slightly greater head excursion values for the HIII-6C than the HII-6C, and similar knee excursion results for the two dummy designs. The excursion results are fairly repeatable, and none of the dummies tested in either CRS approach the head or knee excursion injury criteria value.

HIC Values

Higher HIC values were recorded for the HIII-6C in all cases, for both CRSs tested. This is believed to be due primarily to the difference in neck designs between the Hybrid II and Hybrid III dummy. Curves of the resultant head acceleration for the HII-6C and the HIII-6C are shown in Appendix A, Figures A-4 and A-5, that further illustrate this trend.

Chest Acceleration

Overall, the HIII-6C exhibits a consistent 3 msec chest clip magnitude (**54.0-54.4 G's**), while the HII-6C chest clip varies from 32.0 - 65.8 G's. Some of the variation in the HII-6C values may be due to the different CRSs restraining the dummies. Additionally, the chest acceleration value from the test with the HII-6C seated in the Cosco Grand Explorer exceeds the injury criteria.

B. Three-Year-Old Child

Head & Knee Excursion

The head and knee excursion values presented in Table 2 are not consistently greater for either the HII-3C or the HIII-3C. Both the head and knee excursion values show noticeable variation depending on the type of CRS and belt configuration used. The Cosco Triad with the LATCH¹ system exhibits the least amount of head and knee excursion of any of the CRS tested. The Cosco Touriva secured with the lap belt and no top tether typically demonstrates the greatest head and knee excursion.

¹ "LATCH" stands for "Lower Anchors and Tether for Children," a term that was developed by child restraint manufacturers and retailers to refer to the standardized child restraint anchorage system required by Federal Motor Vehicle Safety Standard No. 225, Child Restraint Anchorage Systems (49 CFR §571.225). This system has two lower anchorages and one tether anchorage. Each lower anchorage includes a rigid round rod or bar onto which the connector of a child restraint system can be snapped. The bars will be located at the intersection of the vehicle seat cushion and seat back. The upper anchorage is a fixture to which the tether of a child restraint system can be hooked. For convenience, this document uses the term "LATCH" in describing the attachment of a child restraint to a Standard No. 225 anchorage system.

HIC Values

The HIC values tend to be greater for the HIII-3C than the HII-3C, though not in all cases. Additionally, HIC values were largest in the Cosco Touriva with the lap belt and no top tether, although the HIC injury criteria was not exceeded in any of the tests.

Chest Acceleration

The 3 msec chest clip values are not substantially greater for either the HII-3C or the HIII-3C. The largest chest resultant acceleration was measured with the HIII-3C in the Cosco Touriva with lap and shoulder belt, although neither three-year-old dummy exceeds the chest acceleration injury criteria in any of the tests.

C. Infant

A comparison of measurement responses between the 9-month-old and the CRABI-12 cannot be conducted since the 9-month-old is non-instrumented. Overall, the CRABI-12 performance is repeatable among sled tests. The small variation in the data presented in Table 3 is primarily due to the type of CRS used and the orientation of the dummy.

Head & Knee Excursion

The head and knee excursion values are consistent for both infant dummies. The 9-month-old measures greater values for both head and knee excursion, although test data is limited.

HIC Values

The CRABI-12 HIC results are consistent and repeatable, and all test results are below the injury criteria value. Contact was observed between the chin and chest in two of the four tests, though this impact does not have a significant effect on the HIC values.

Chest Acceleration

The 3 msec chest clips measured by the CRABI-12 are higher in the forward-facing configuration than the rear-facing configuration. Both tests with the dummy facing forward measure chest accelerations above the injury criteria.

V. Conclusions

1. The HIII-6C measures slightly greater head excursion results and larger HIC values than the HII-6C, due primarily to the different neck designs. The knee excursion and 3 msec chest clip are not consistently greater for either dummy, although the chest acceleration values measured with the HIII-6C are more consistent than those of the HII-6C.
2. No significant differences are observed between the performance of the HII-3C

and the HIII-3C. Test results show dummy performance to be reliant more on CRS model and belt configuration employed rather than dummy type.

3. The CRABI-12 provides consistent, repeatable results among the four sled tests conducted. The forward-facing dummy recorded higher chest acceleration than the rear-facing dummy, while the HIC values are relatively similar regardless of dummy orientation.
4. The sled test results show fairly consistent dummy performance with the Hybrid II and Hybrid III child dummies. Some variation in response is noted when different CRS and belt configurations are used.

Appendix A

Sled Test Results

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TRC of Ohio

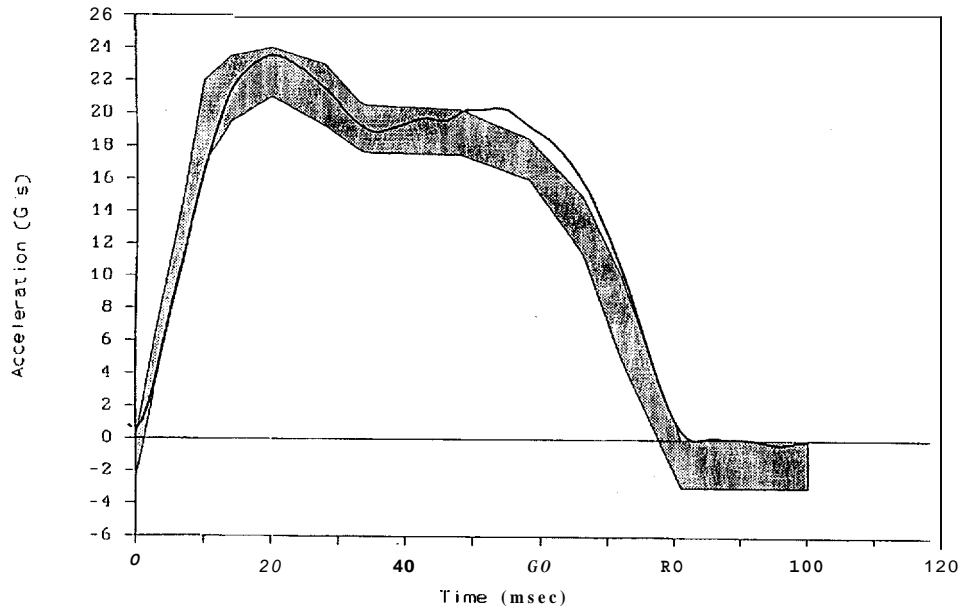


Figure A-1. Sled acceleration time history with corridors for FMVSS 213 pulse at VRTC test facility

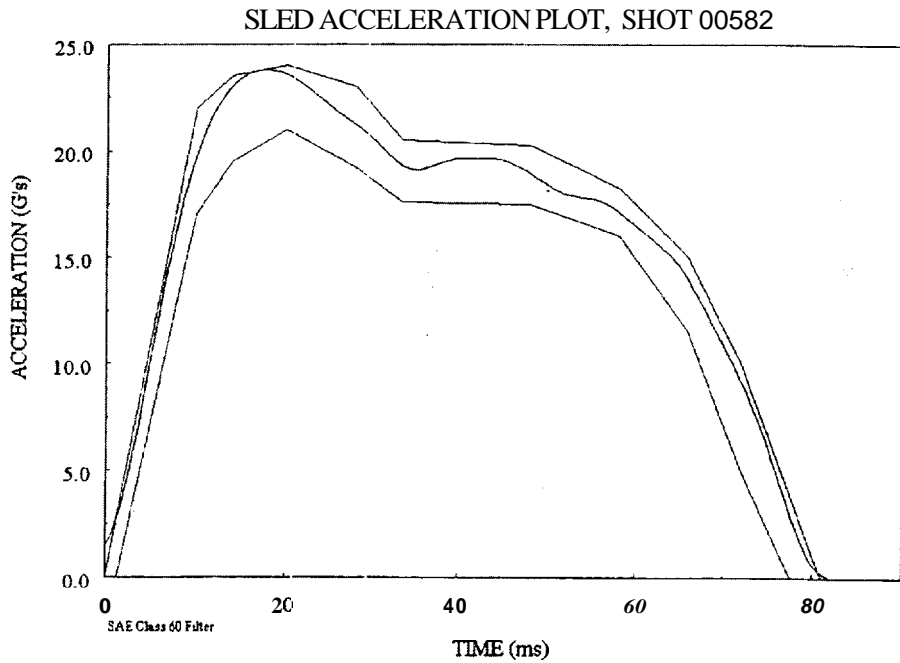
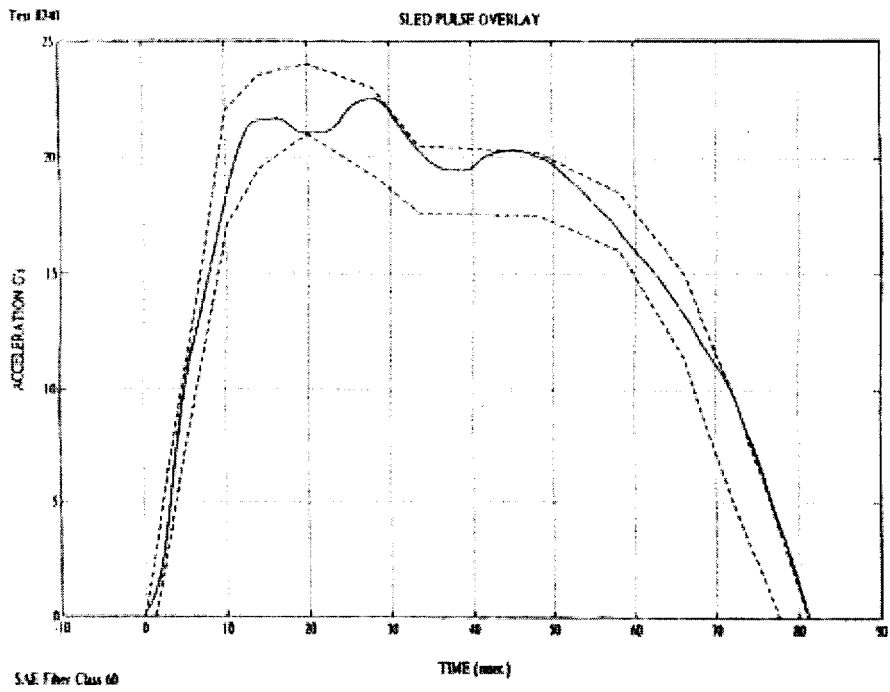


Figure A-2. Sled acceleration time history with corridors for FMVSS 213 pulse at Pax River test facility



FMVSS 213 30 MPH PULSE ENVELOPE

Figure A-3. Sled acceleration time history with corridors for FMVSS 213 pulse at Veridian test facility

Six-Year-Old Child Dummy

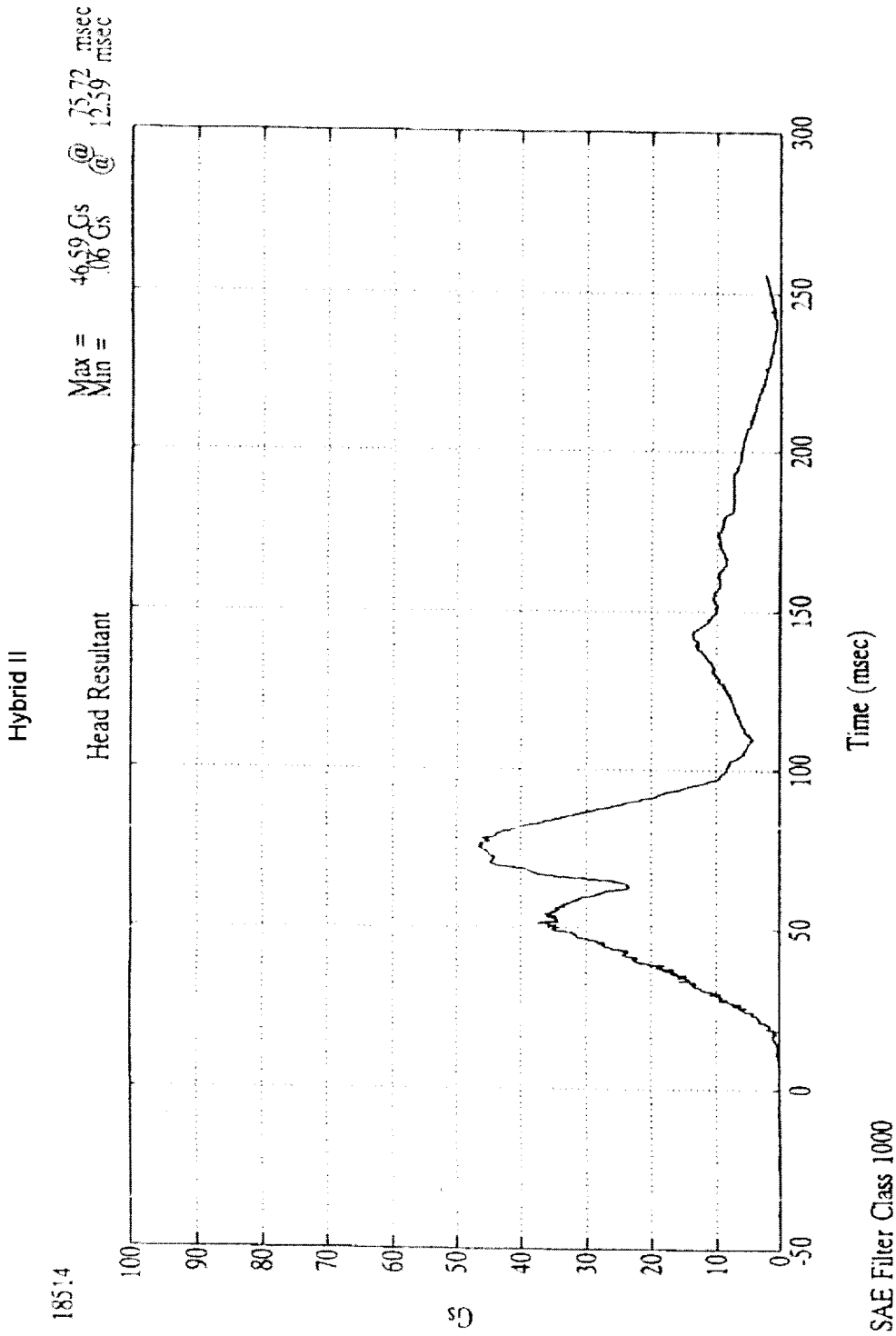
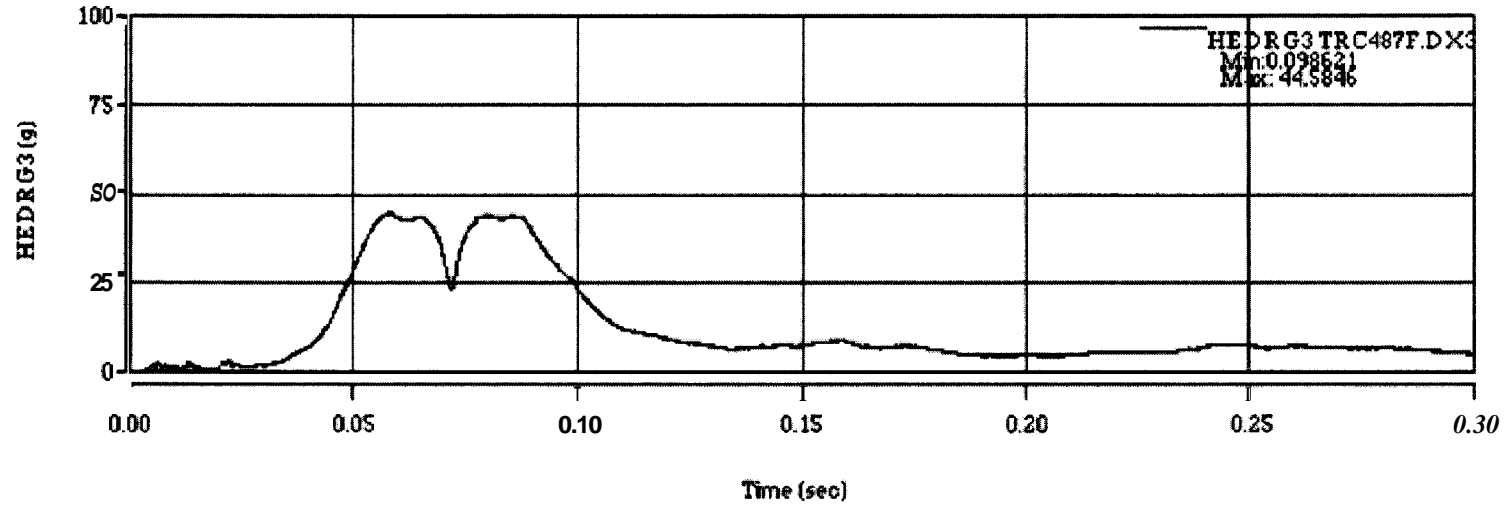


Figure A-4a. Head resultant acceleration time history for Hybrid II six-year-old dummy in Cosco Grand Explorer w/ lap/shoulder belt

Hybrid II



Hybrid III

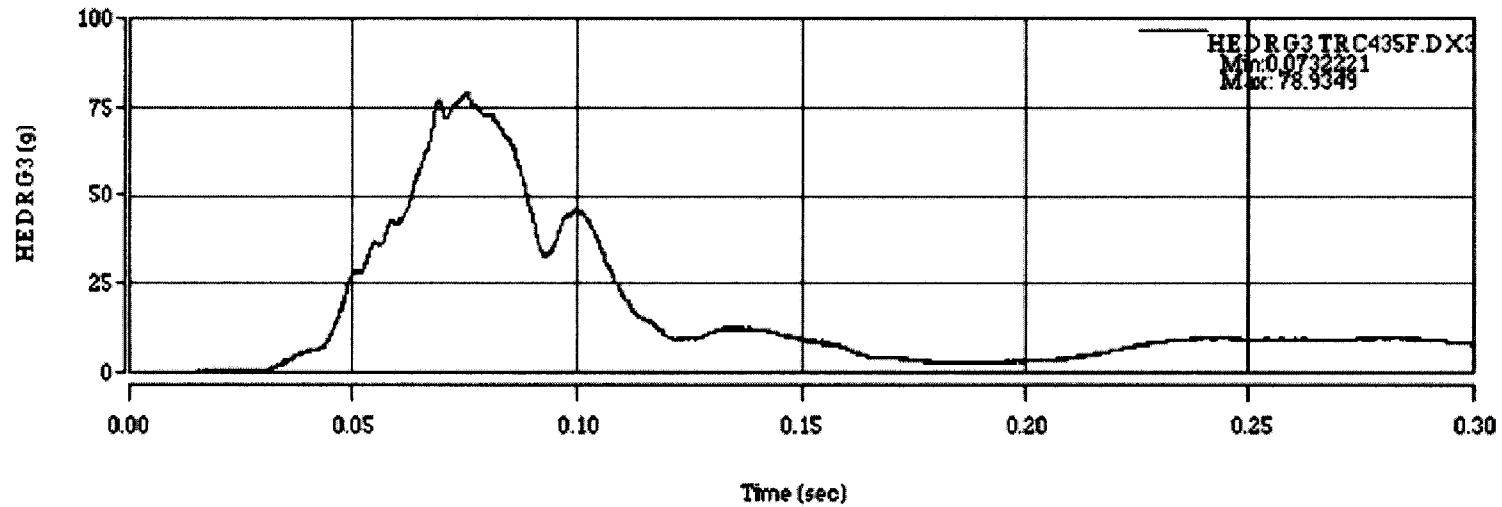


Figure A-4b. Head resultant acceleration time histories for Hybrid II and Hybrid III six-year-old dummies in Cosco Grand Explorer w/ ladshoulder belt

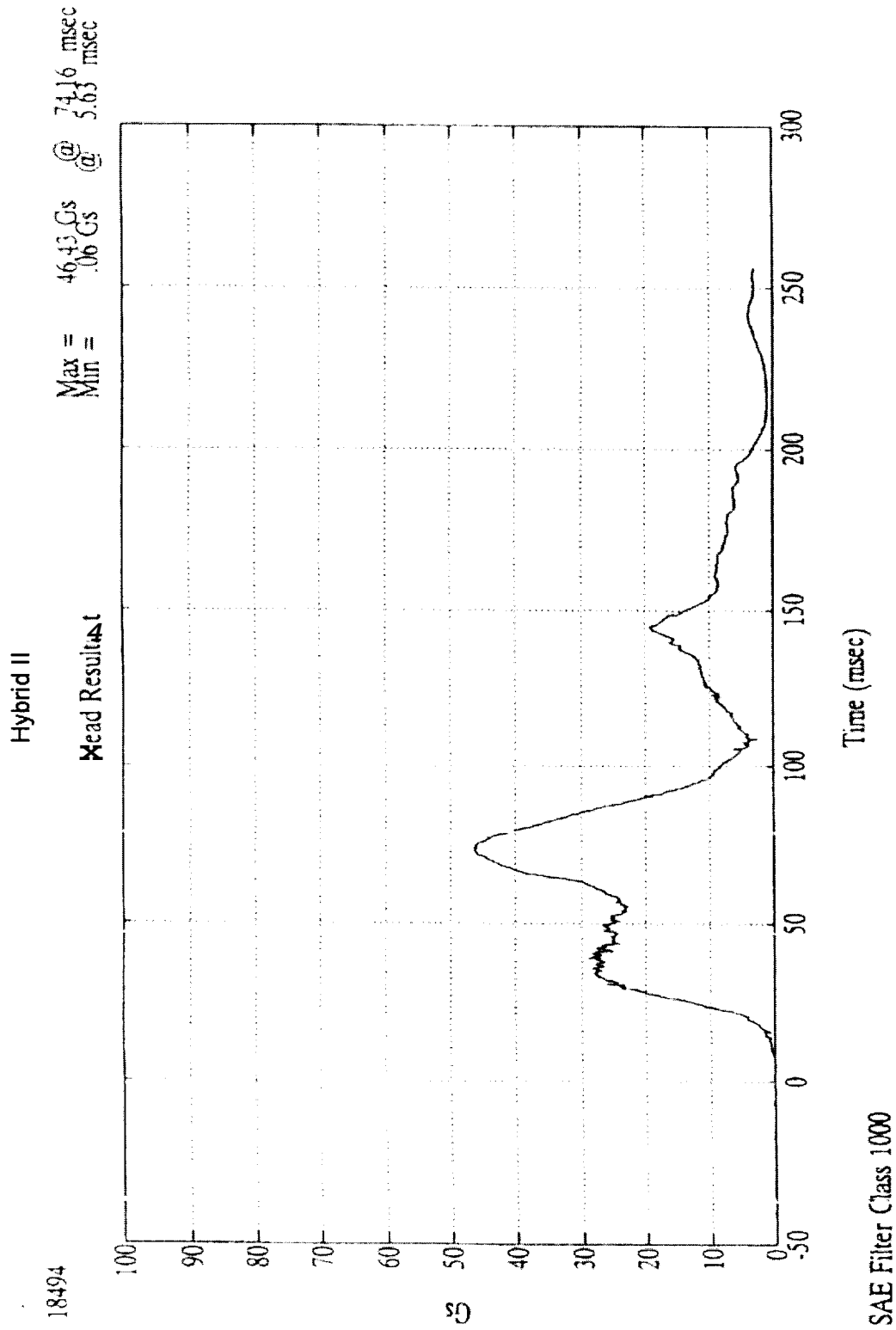


Figure A-5a. Head resultant acceleration time history for Hybrid II six-year-old dummy in Century Breverra Classic w/ lap/shoulder belt

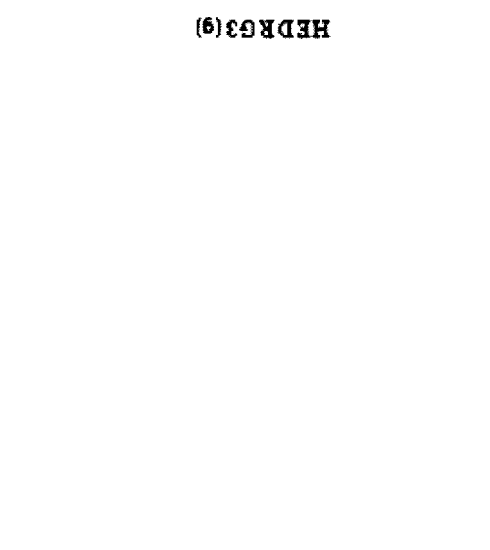
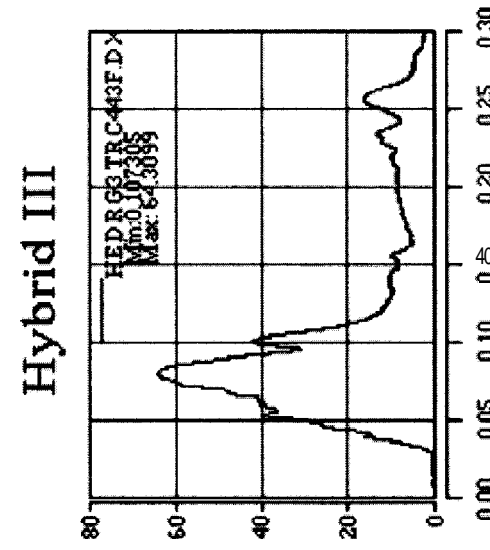
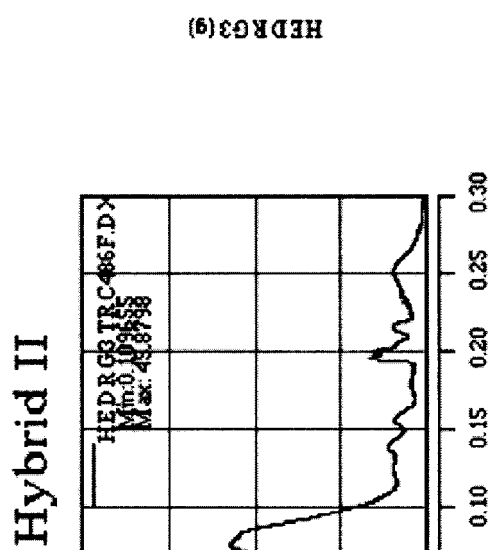
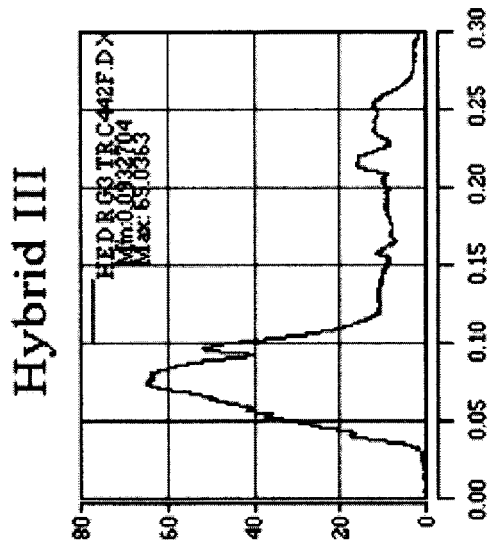


Figure A-5b. Head resultant acceleration time histories for Hybrid II and Hybrid III six-year-old dummies in Century lap/shoulder belt w/

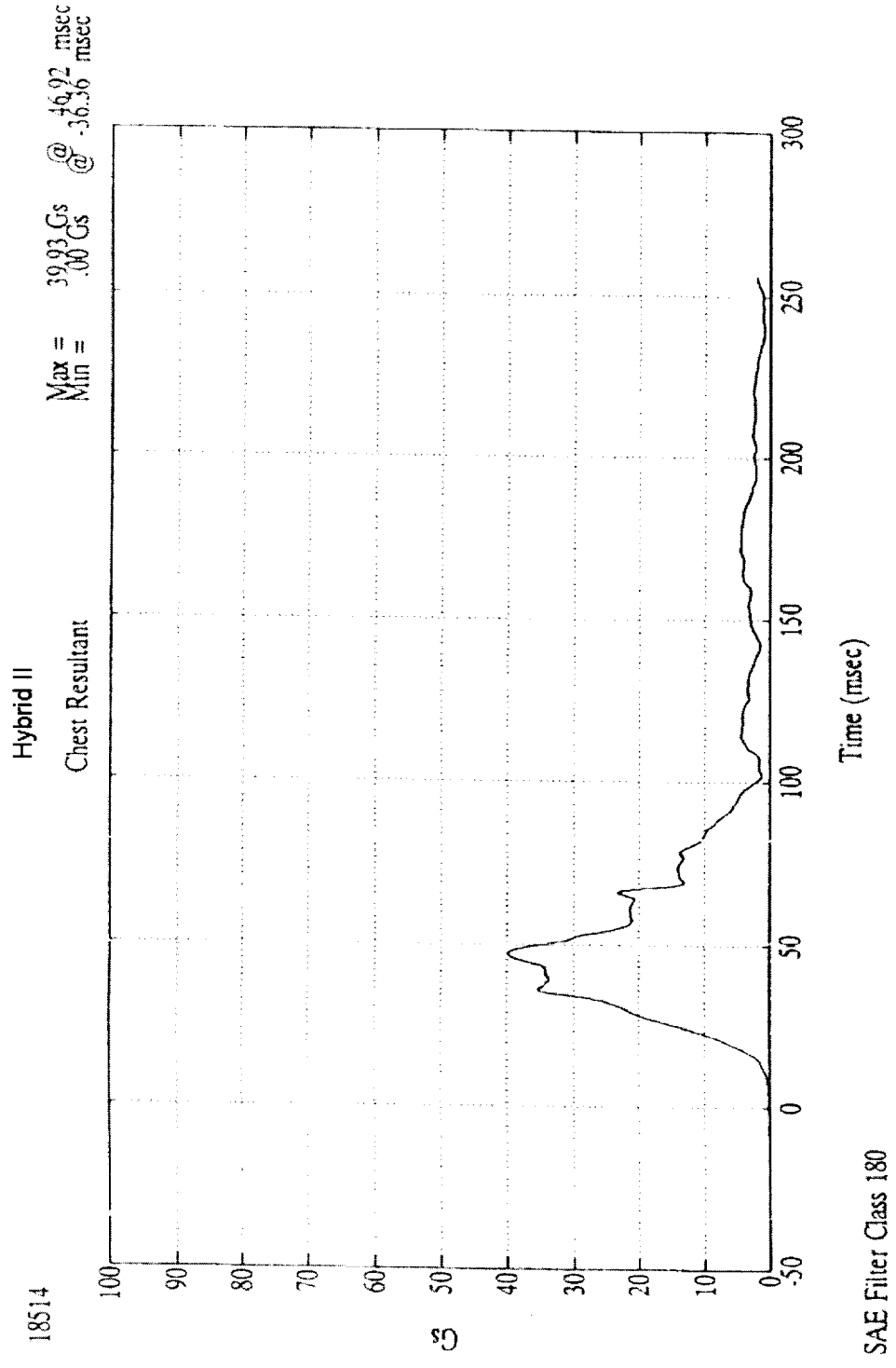
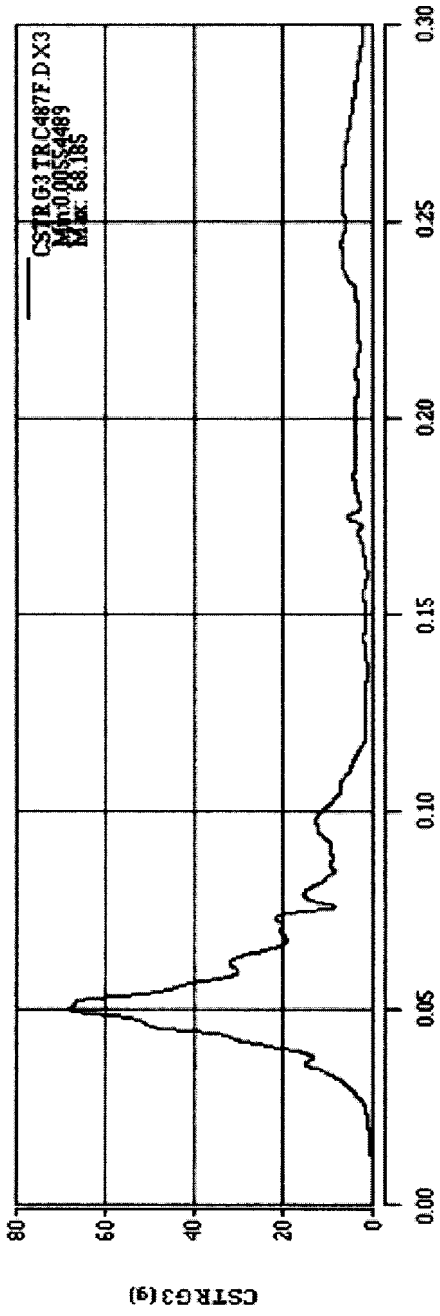


Figure A-6a. Chest resultant acceleration time history for Hybrid II six-year-old dummy in Cosco Grand Explorer car lap/shoulder belt

Hybrid II



Hybrid III

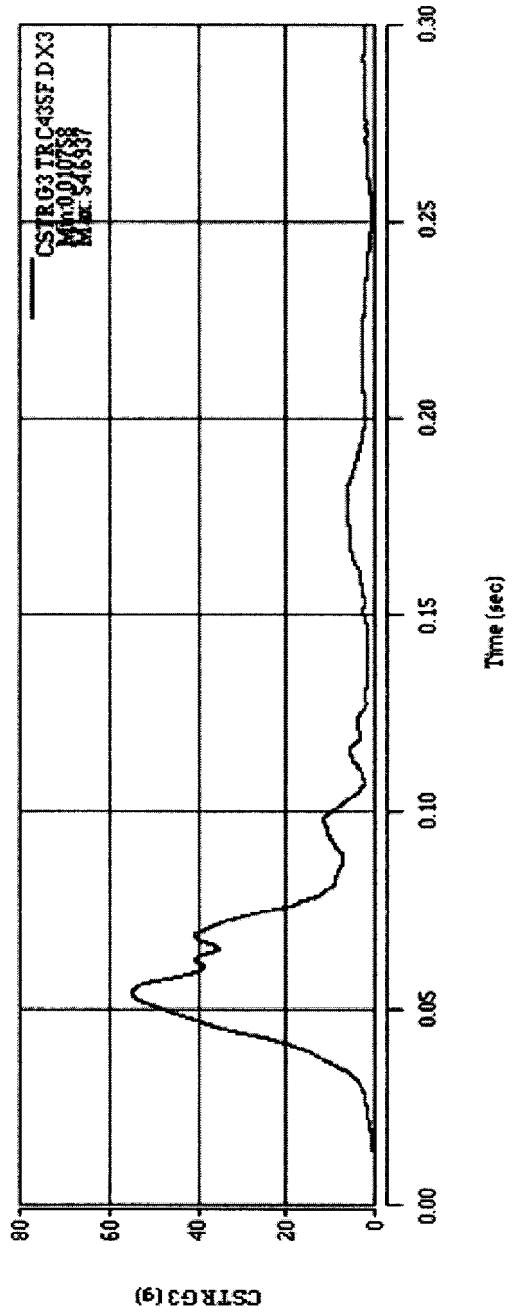


Figure A-6b. Chest resultant acceleration time histories for Hybrid II and Hybrid III six-year-old dummies in Cosco Gran® Explorer w/ lap/shoulder belt

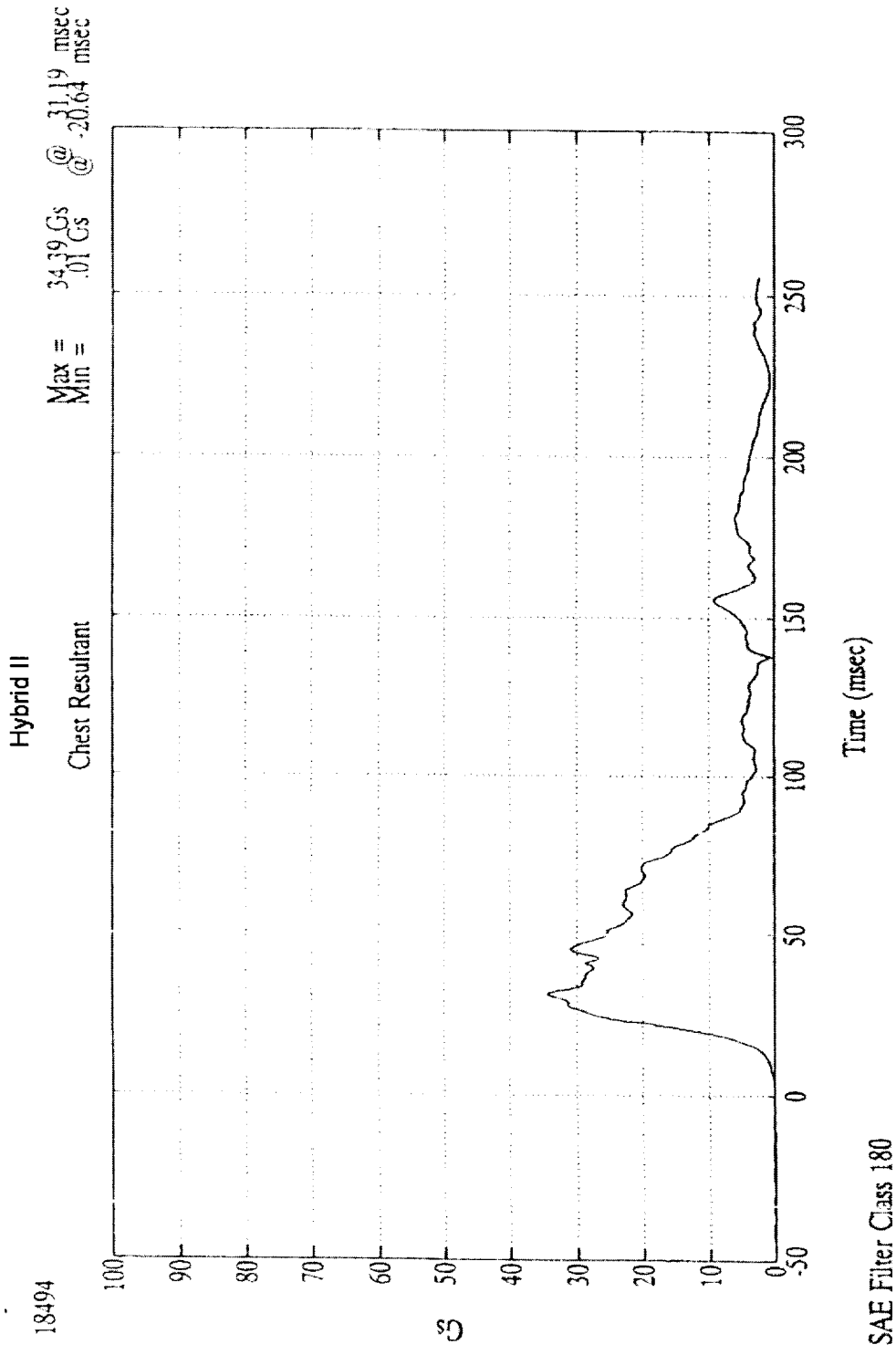
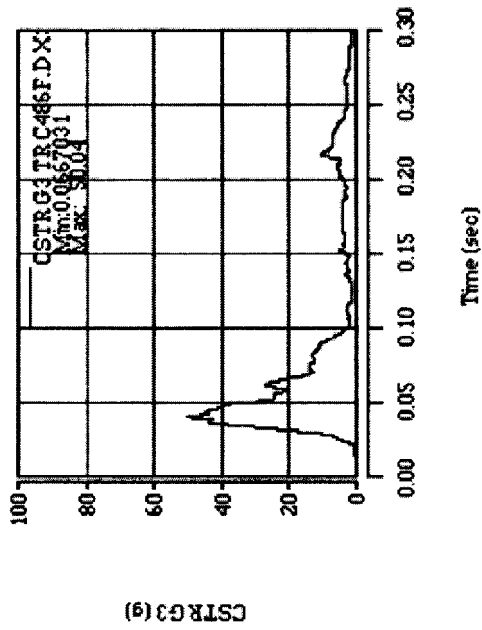
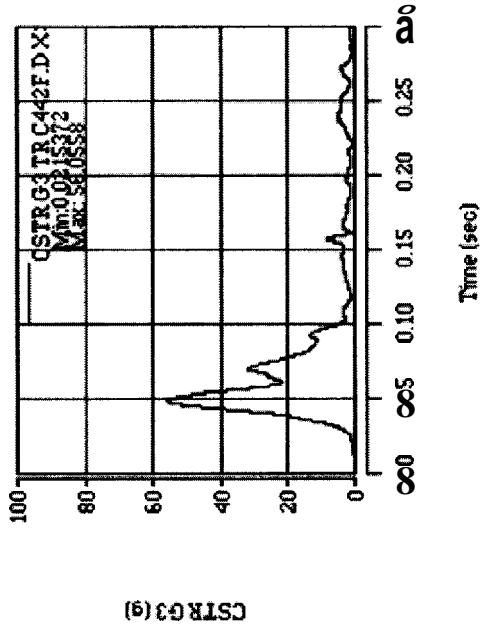


Figure A-7a. Chest resultant acceleration time history for Hybrid II six-year-old dummy in Century Breverra Classic w/ lap/shoulder belt

Hybrid II



Hybrid III



Hybrid III

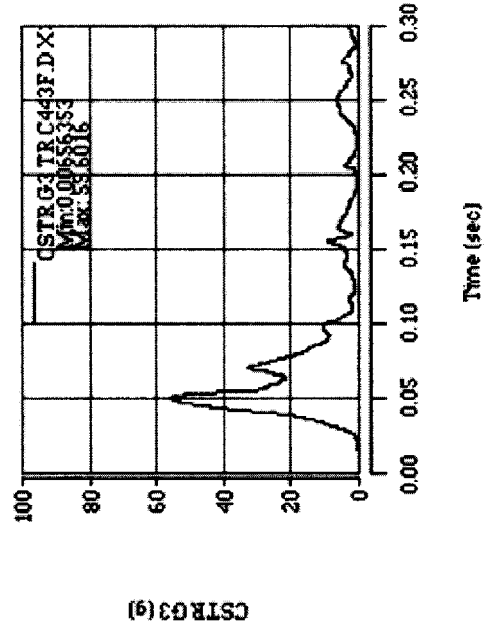


Figure A-7b. Chest resultant acceleration time histories for Hybrid II and Hybrid III six-year-old dummies in Century Brevera Classic w/ lap/shoulder belt

Three-Year-Old Child Dummy

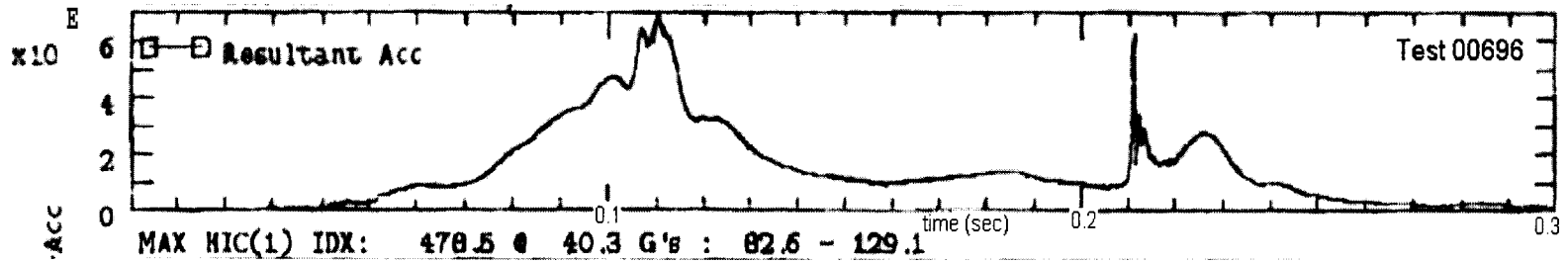


Figure A-8a. Head resultant acceleration time history for Hybrid II three-year-old dummy in Cosco Touriva w/ lap belt only

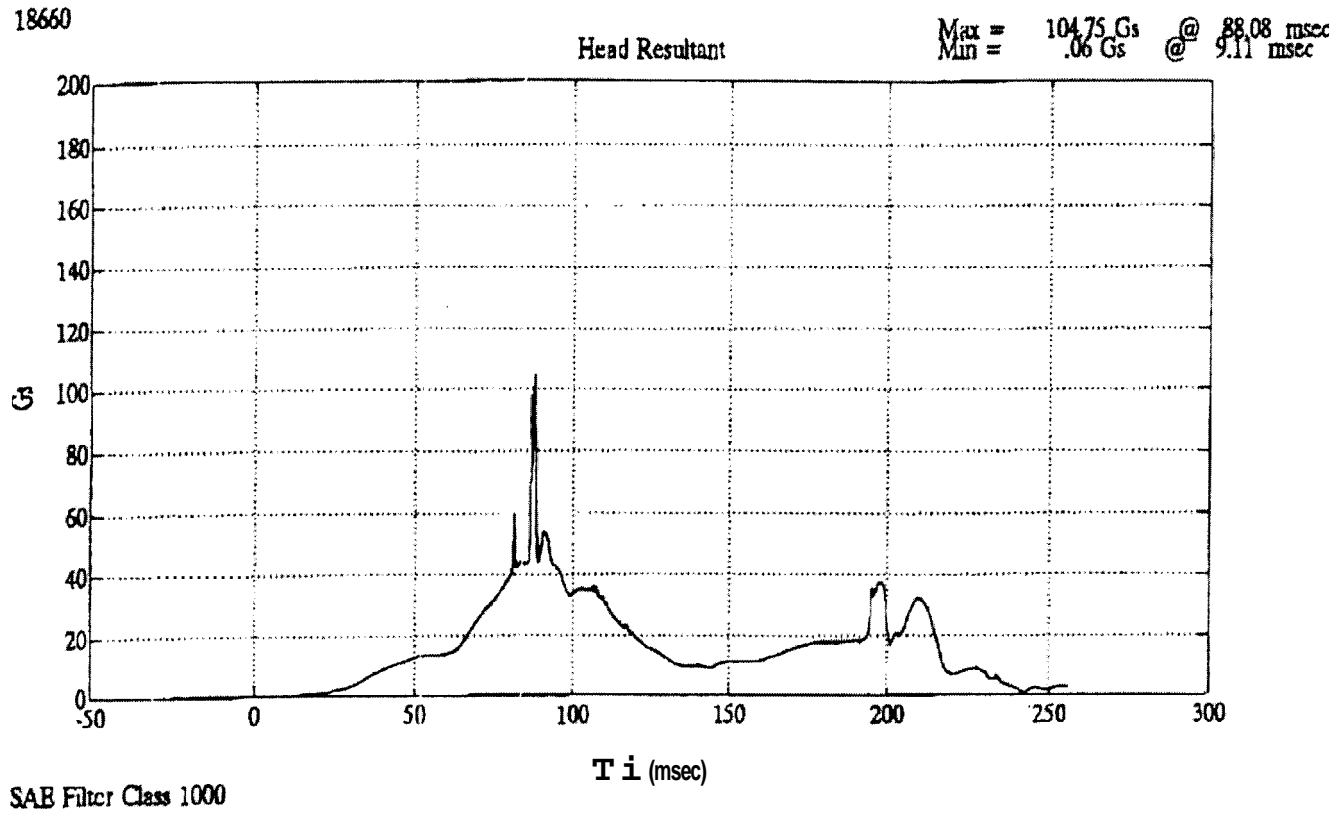
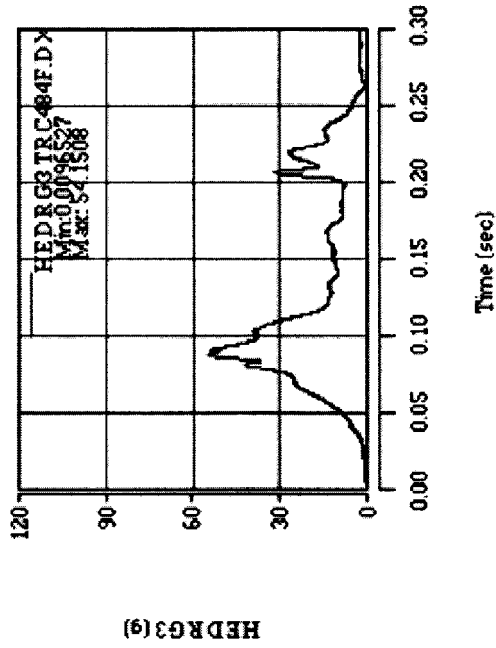


Figure A-8b. Head resultant acceleration time history for Hybrid II three-year-old dummy in Cosco Touriva w/ lap belt only

Hybrid II



Hybrid III

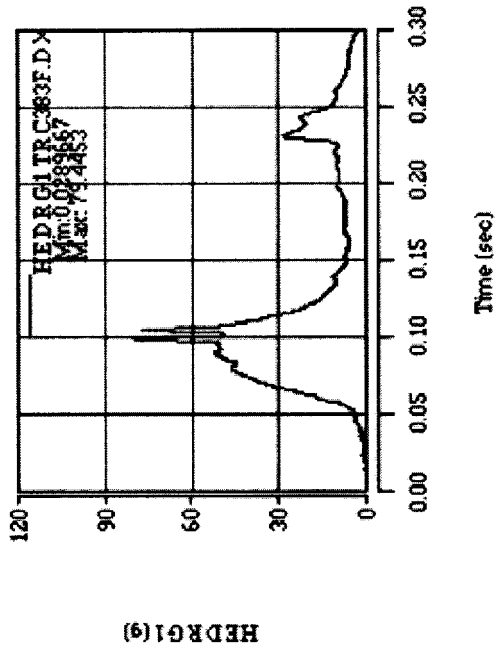


Figure A-8c. Head resultant acceleration time histories for Hybrid II and Hybrid III three-year-old dummies in Cosco Touriva w/ lap belt only (Note: CRS in test TRC 425 is restrained with the lap/shoulder belt)

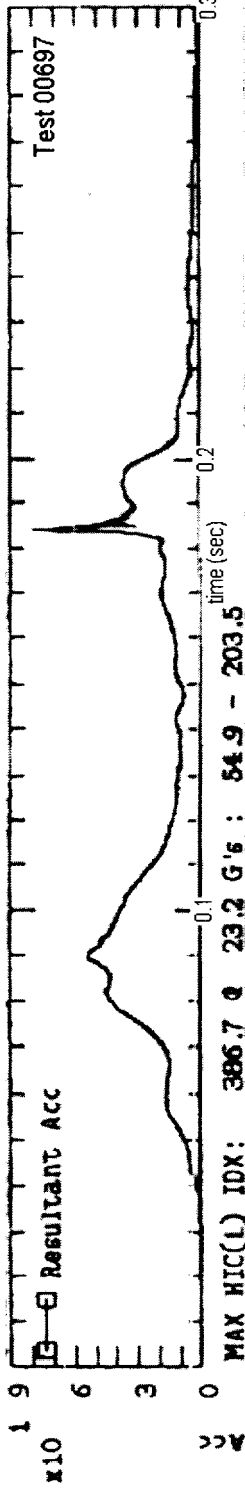


Figure A-9a. Head resultant acceleration time history for Hybrid II three-year-old dummy in Cosco Touriva w/ lap belt/top tether

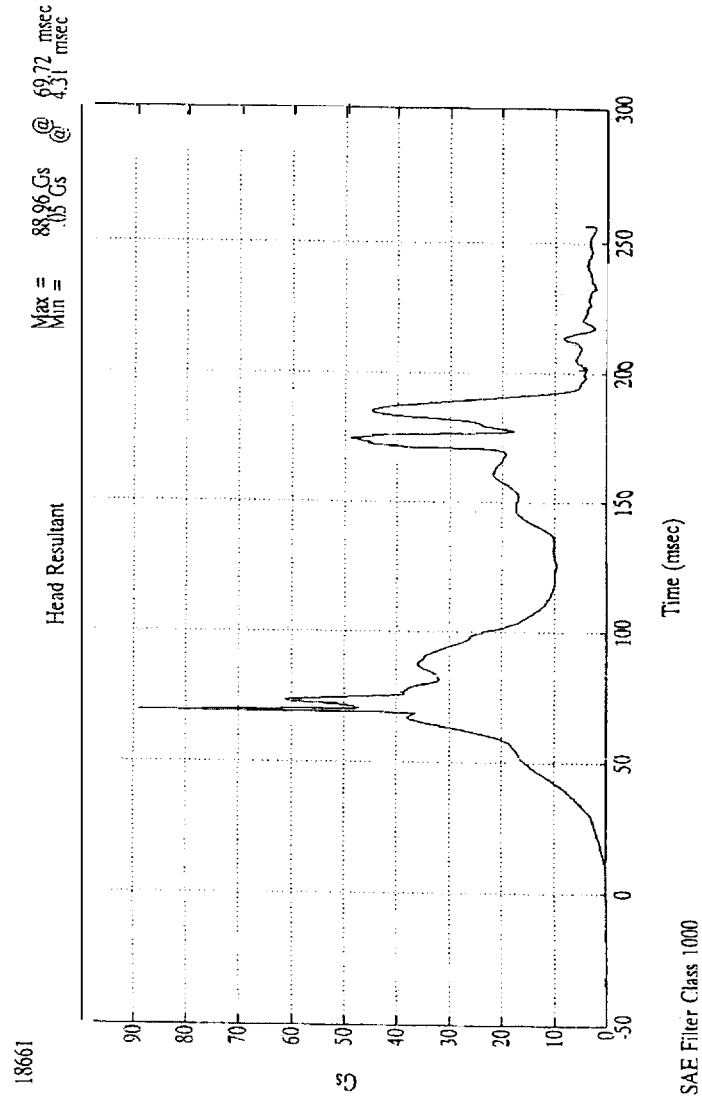
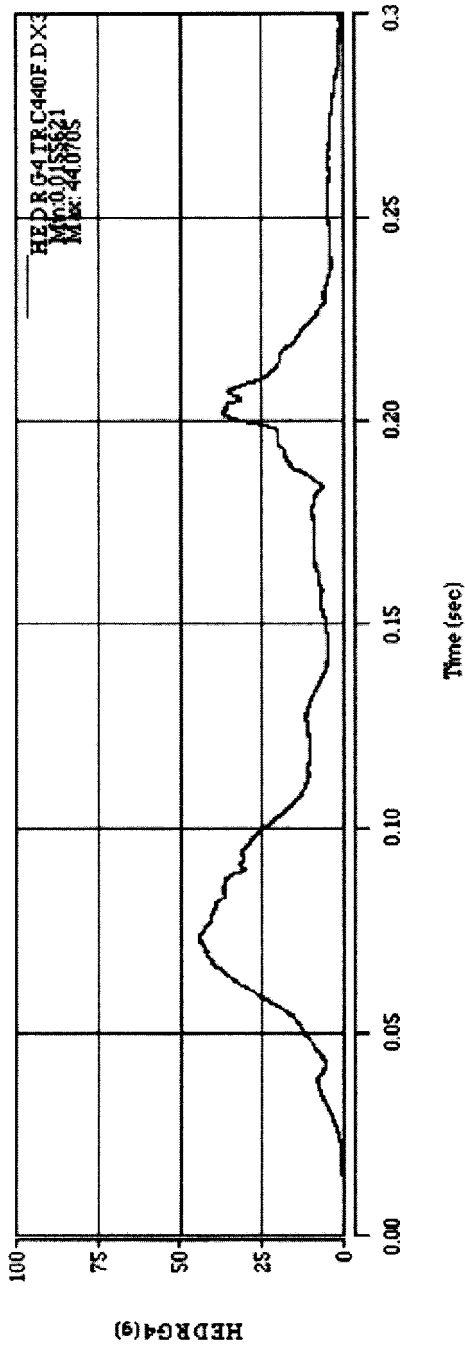


Figure A-9b. Head resultant acceleration time history for Hybrid II three-year-old dummy in Cosco Touriva w/ lap belt/top tether

Hybrid III



Hybrid III

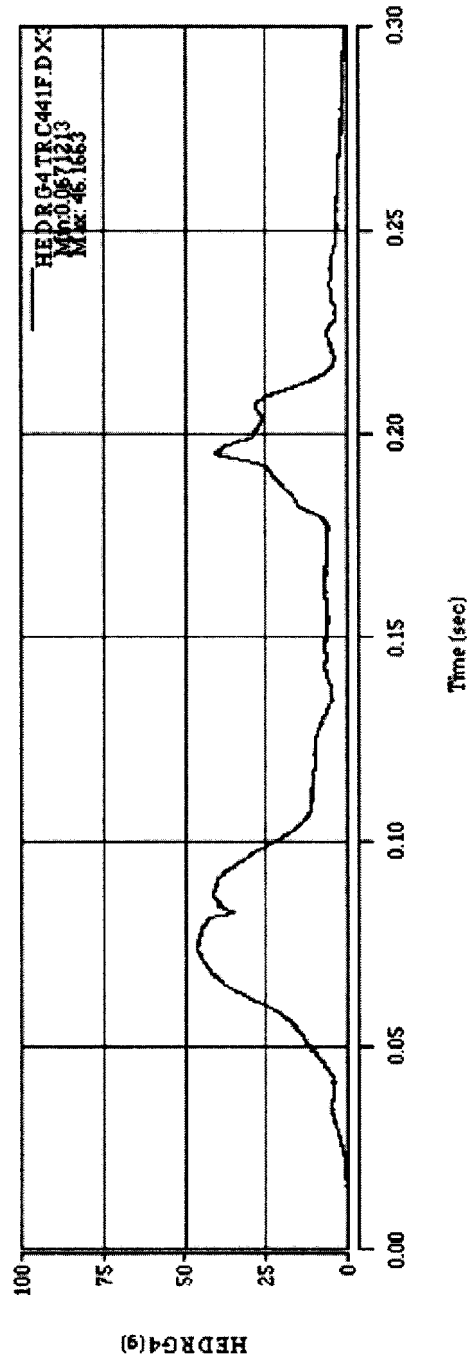


Figure A-9c. Head resultant acceleration time histories for Hybrid III three-year-old dummies in Cosco Touriva w/ lap belt/top tether

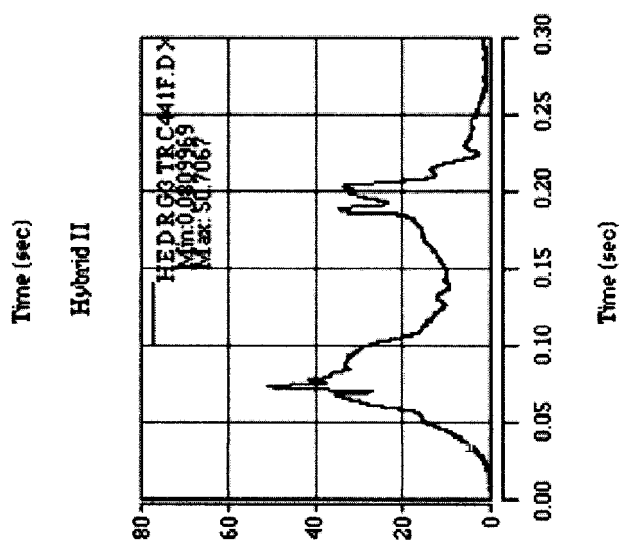
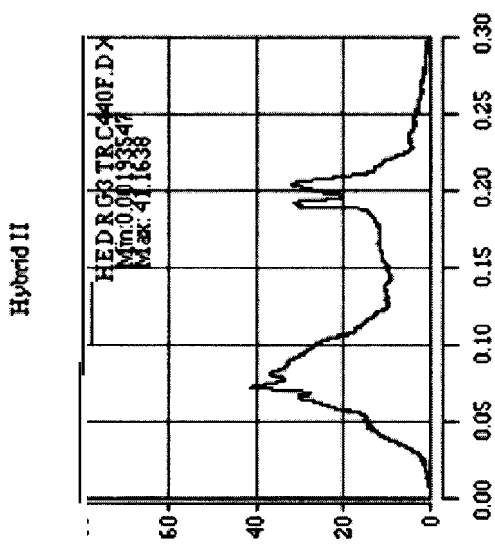
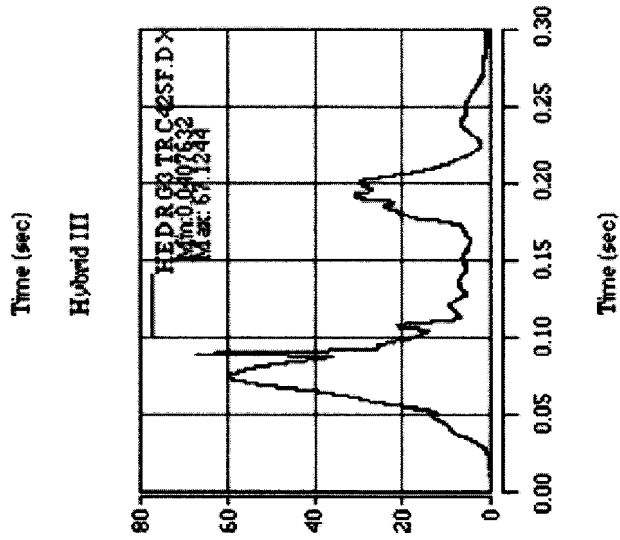
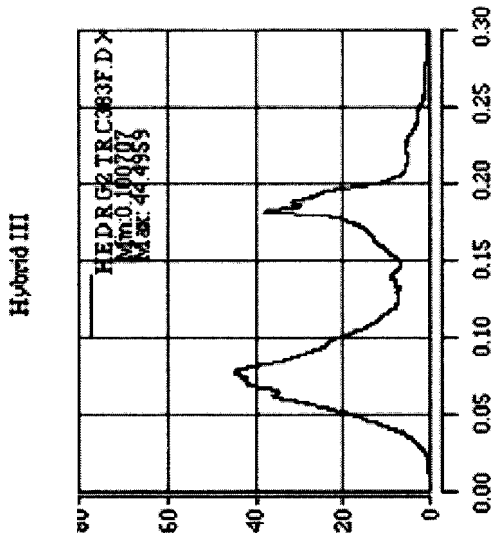


Figure A-10. Head resultant acceleration time histories for Hybrid I and Hybrid III three-year-old dummies in Cosco Triad w/ LATCH

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Head Resultant
Max = 78.09 Gs @ 69.00 msec
Min = .07 Gs @ 4.55 msec

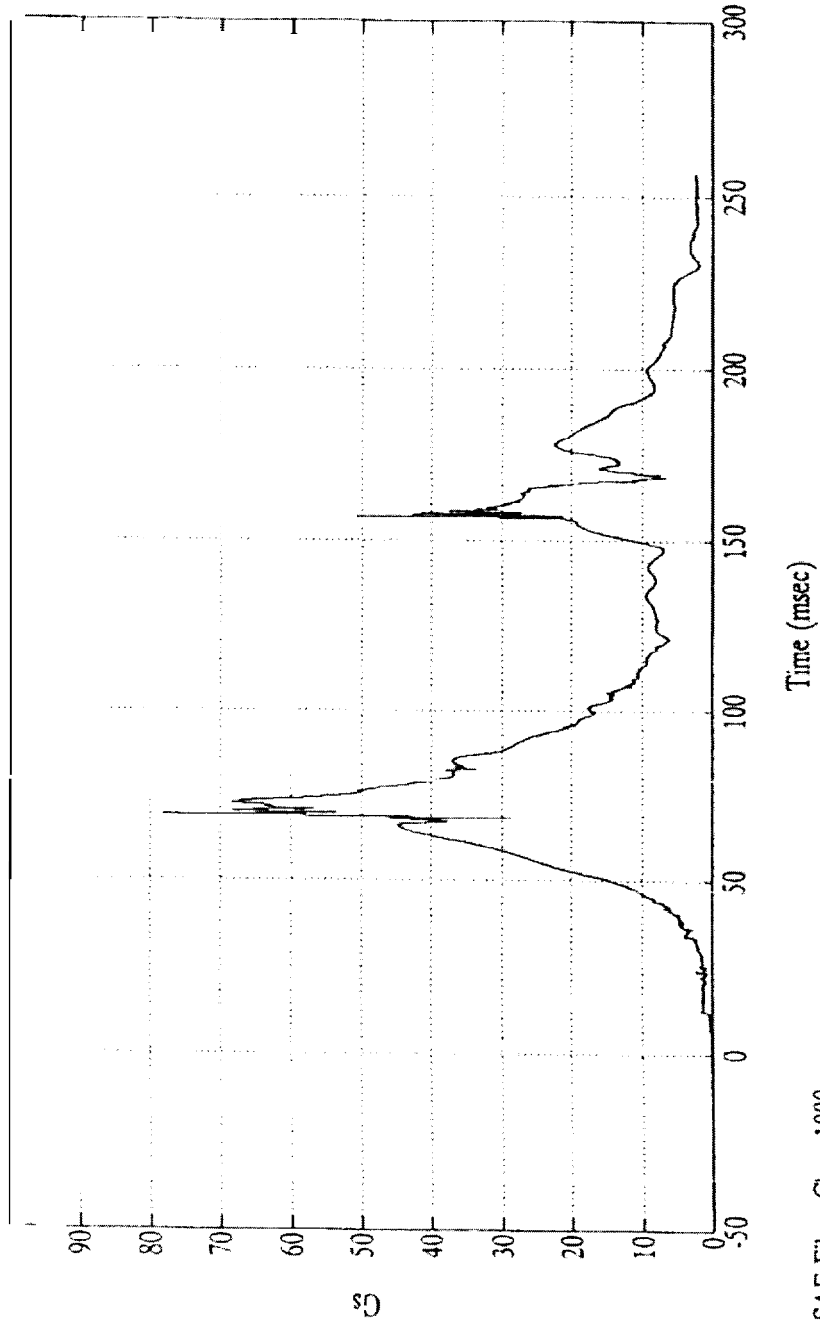


Figure A-11a. Head resultant acceleration time history for Hybrid II three-year-old dummy in Century Breverra Classic w/ lap belt/top tether

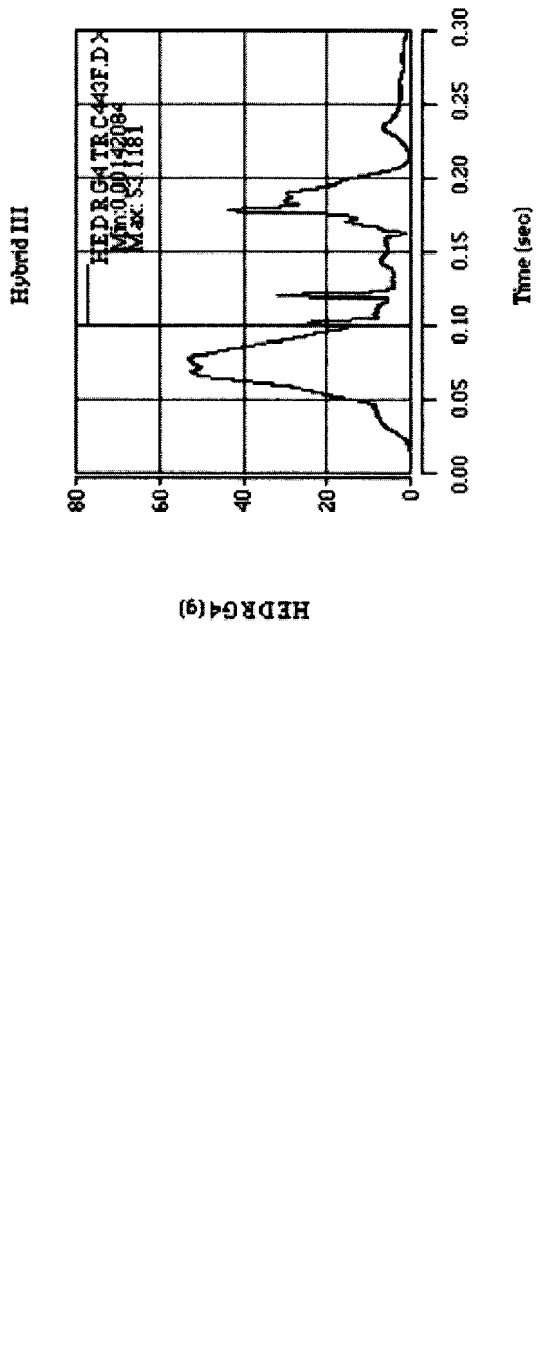
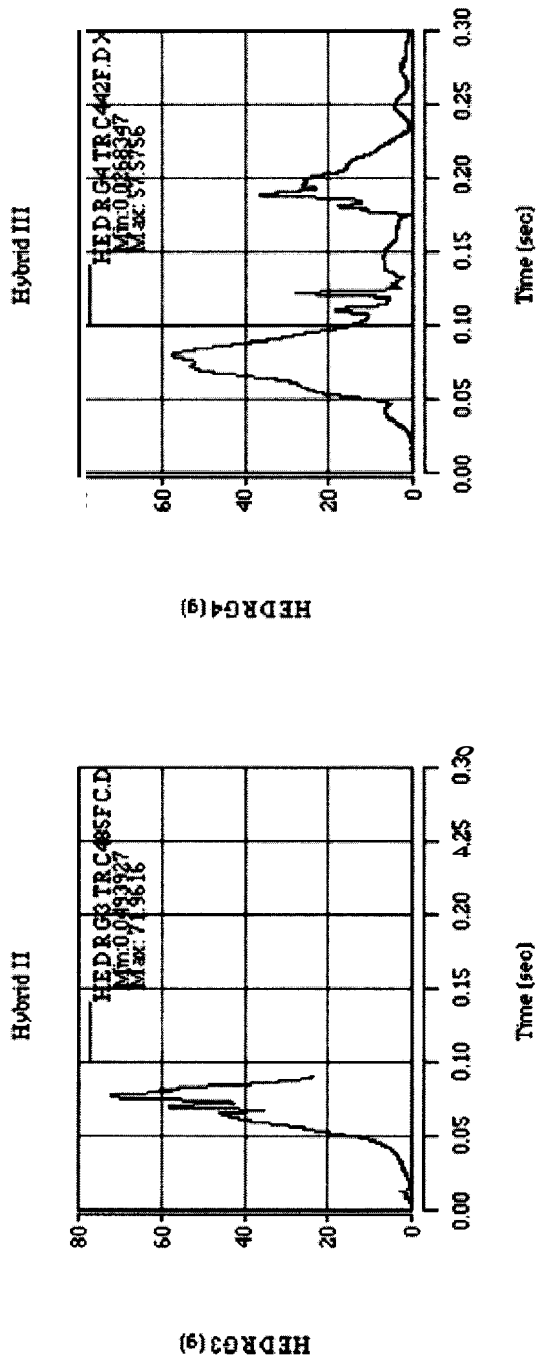


Figure A-11b. Head resultant acceleration time histories for Hybrid II and Hybrid III three-year-old dummies in Century Breverra Classic w/ lap belt/top tether

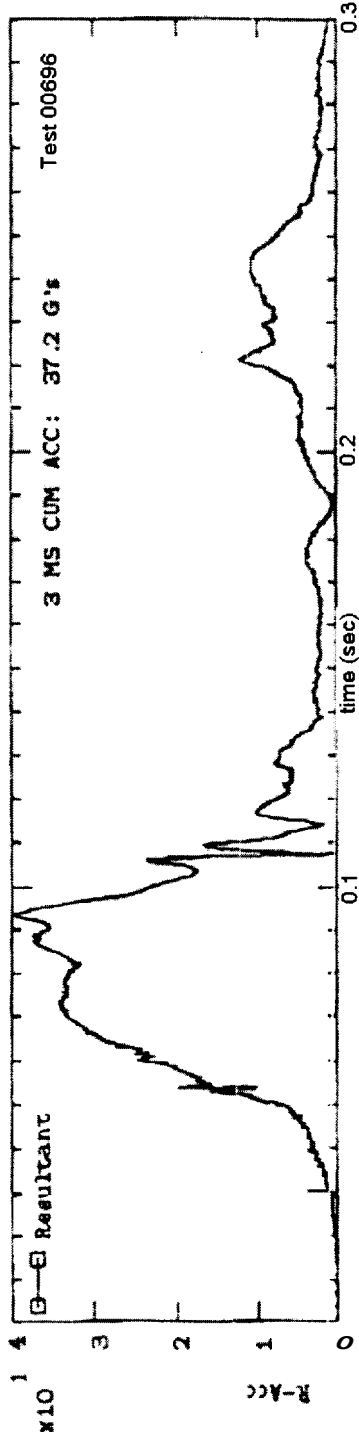


Figure A-12a. Chest resultant acceleration time history for Hybrid II three-year-old dummy in Cosco Touriva w/ lap belt only

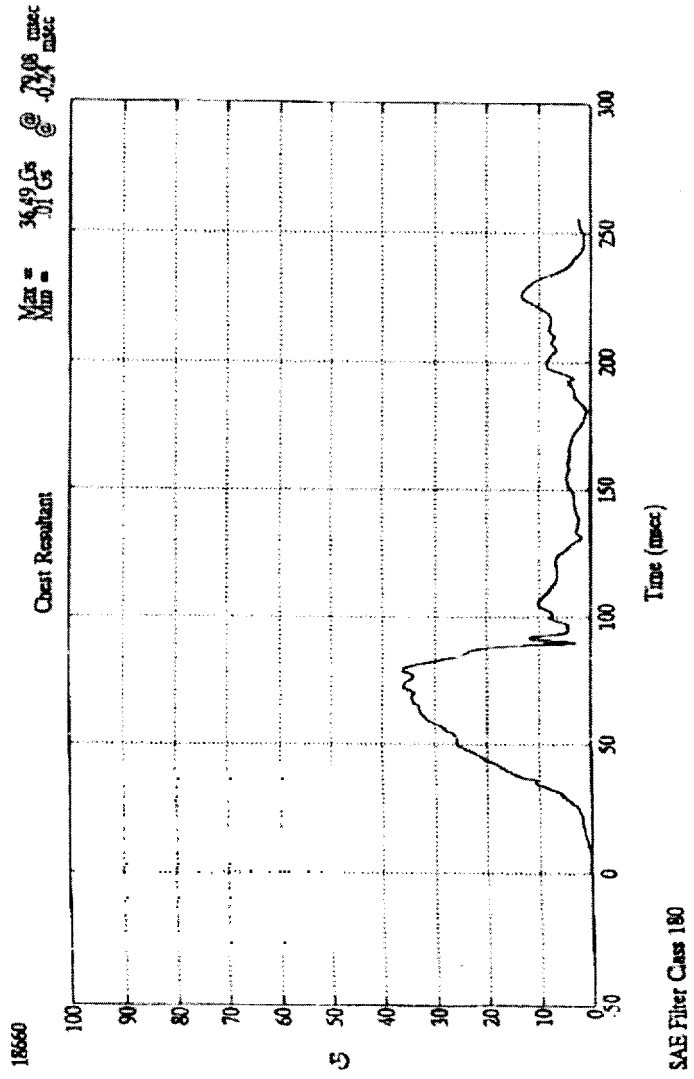


Figure A-12b. Chest resultant acceleration time history for Hybrid II three-year-old dummy in Cosco Touriva w/ lap belt only

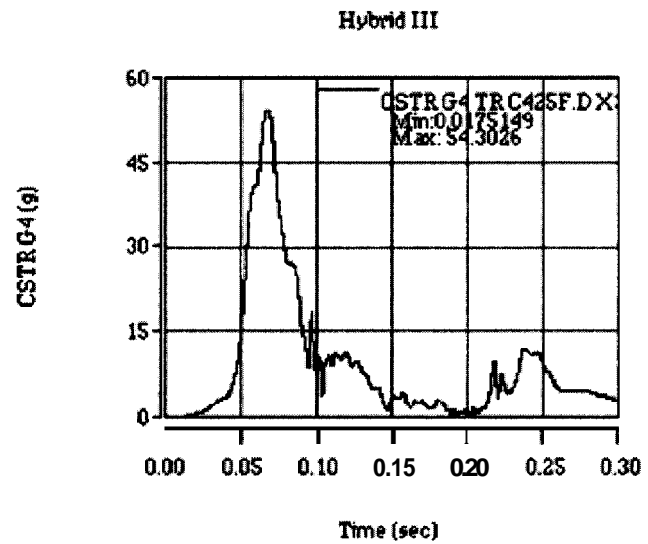
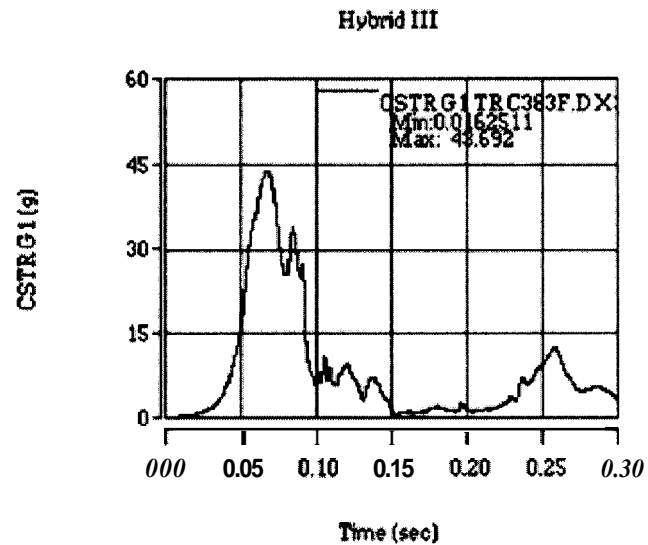
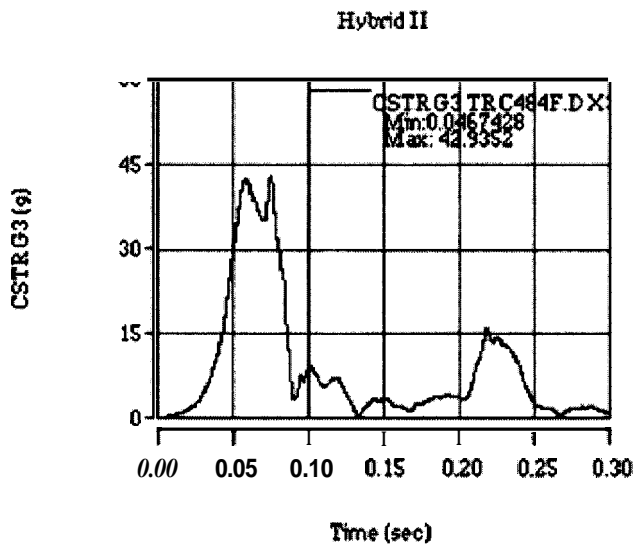


Figure A-12c. Chest resultant acceleration time histories for Hybrid II and Hybrid III three-year-old dummies in Cosco Touriva w/ lap belt only (Note: CRS in test TRC425 is restrained with the lap/shoulder belt)

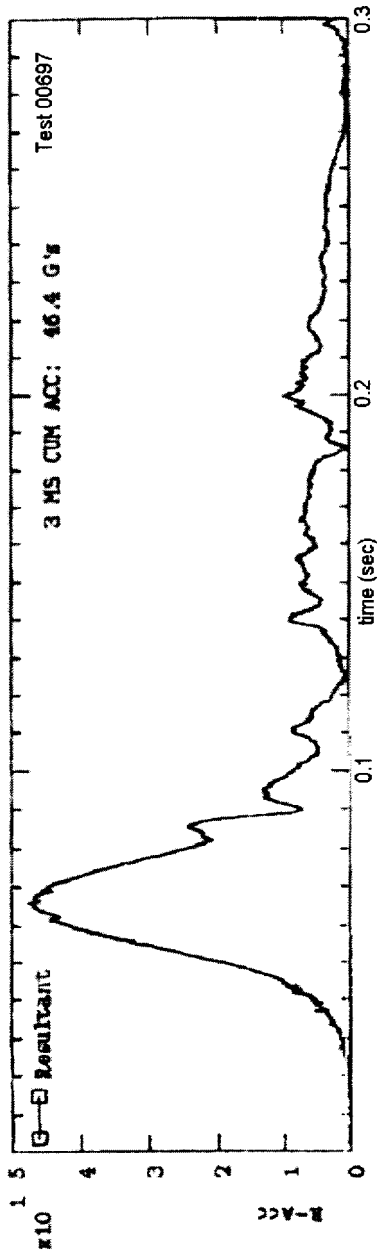


Figure A-13a. Chest resultant acceleration time histories for Hybrid II three-year-old dummy in Cosco Touriva w/ lap belt/ top tether

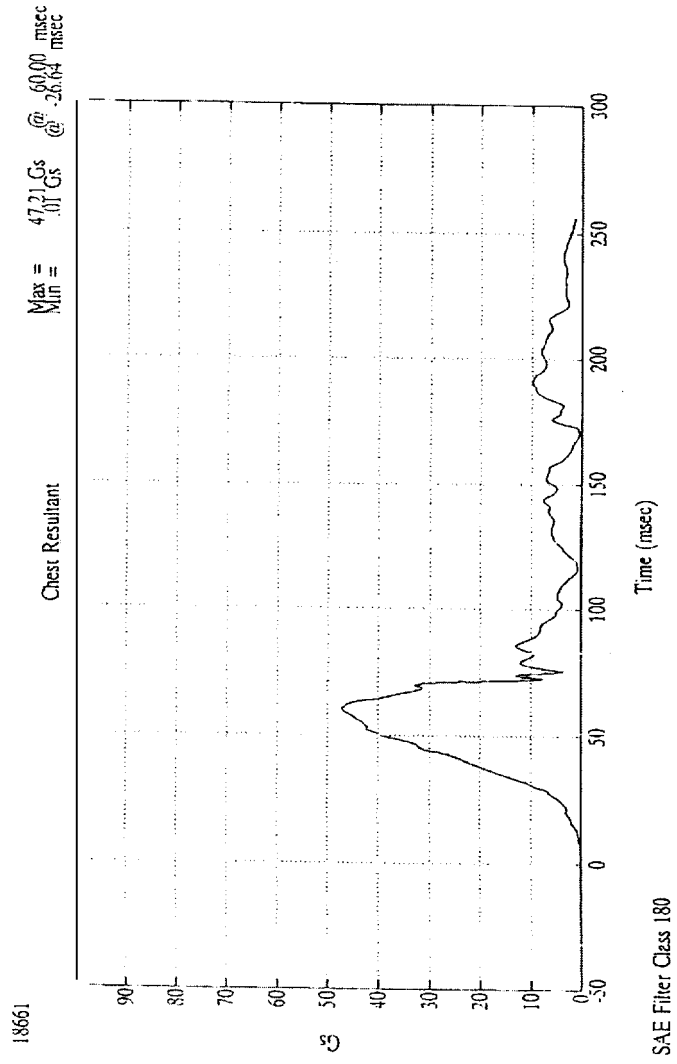
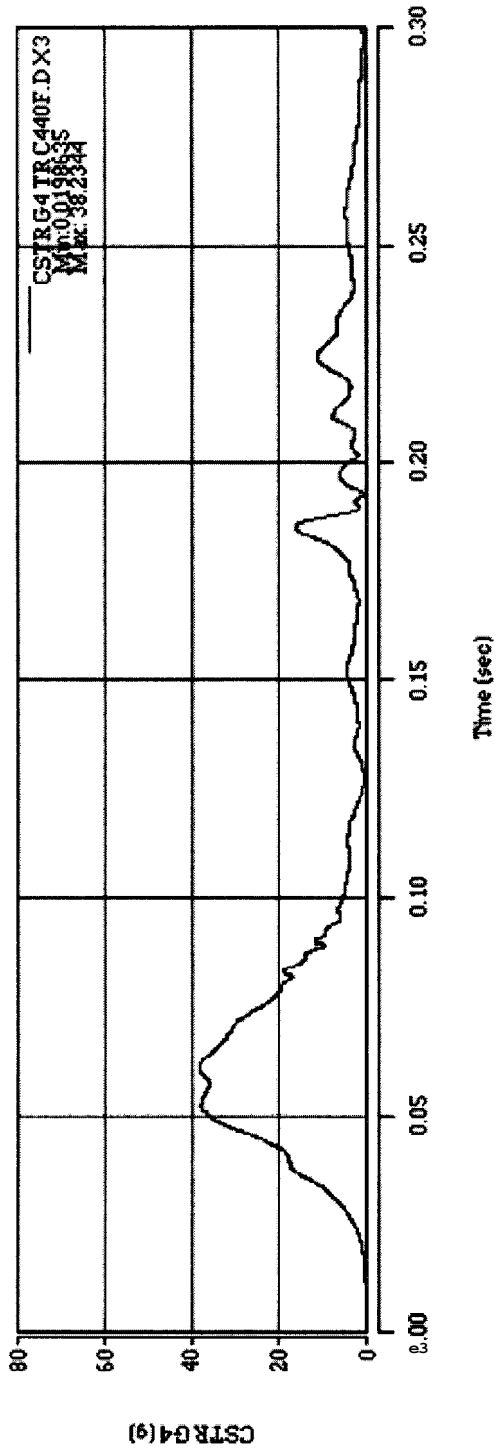


Figure A-13b. Chest resultant acceleration time history for Hybrid II three-year-old dummy in Cosco Touriva w/ lap belt/top tether

Hybrid III



Hybrid III

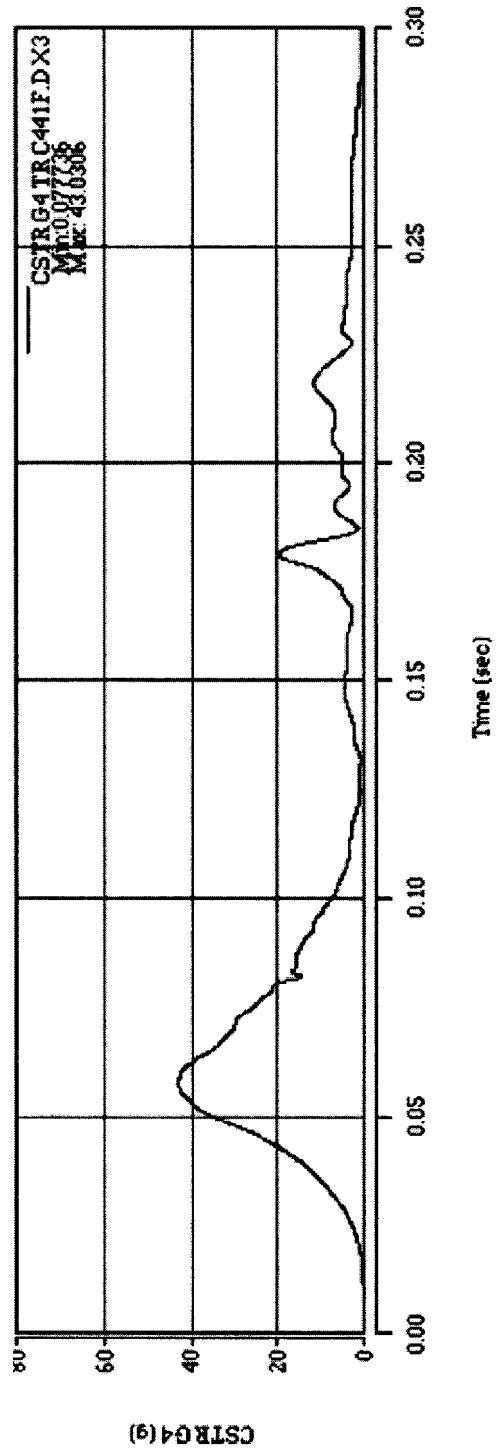


Figure A-13c. Chest resultant acceleration time history for Hybrid III three-year-old dummies in Cosco Touriva w/ lap belt/top tether

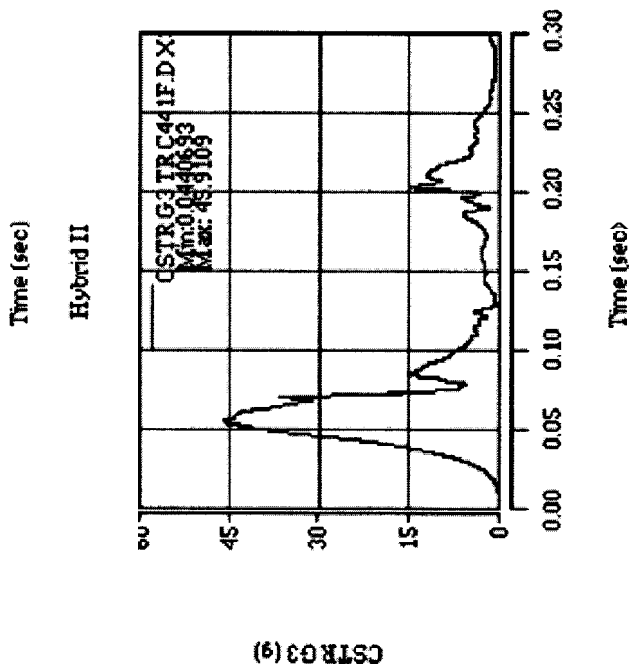
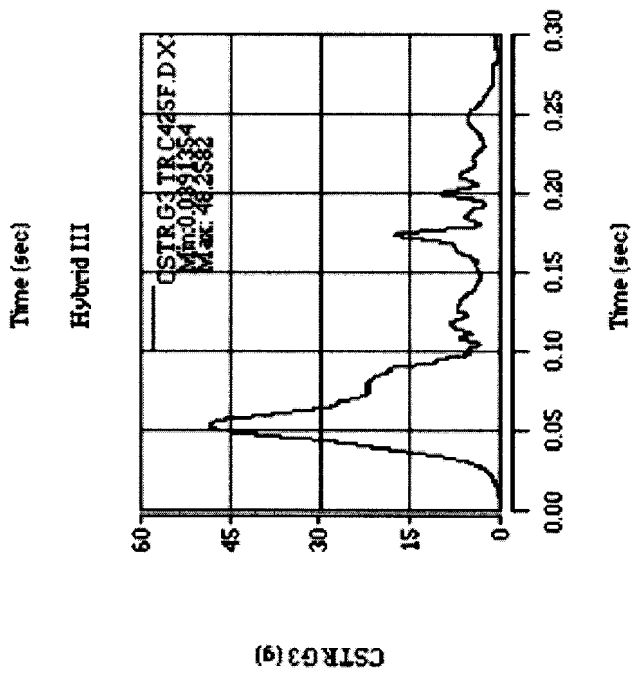
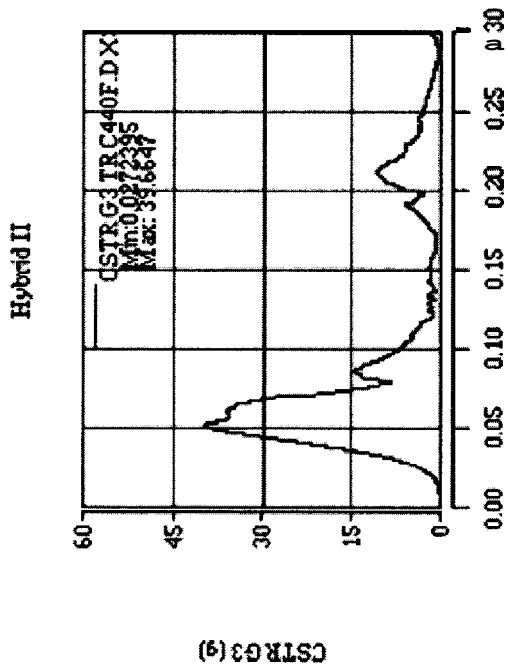
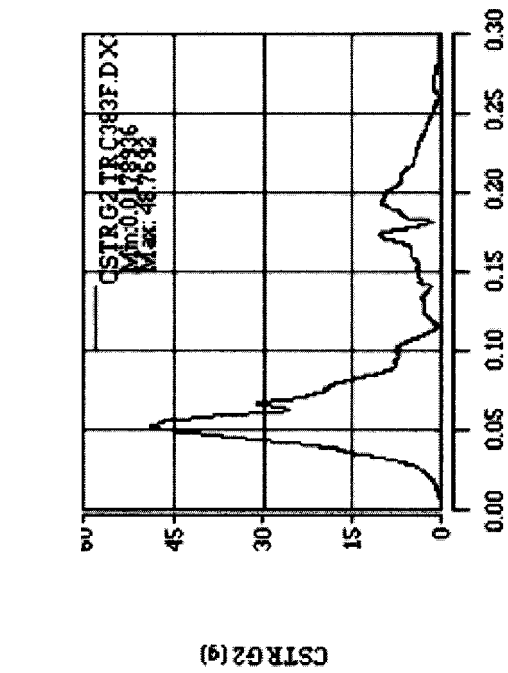
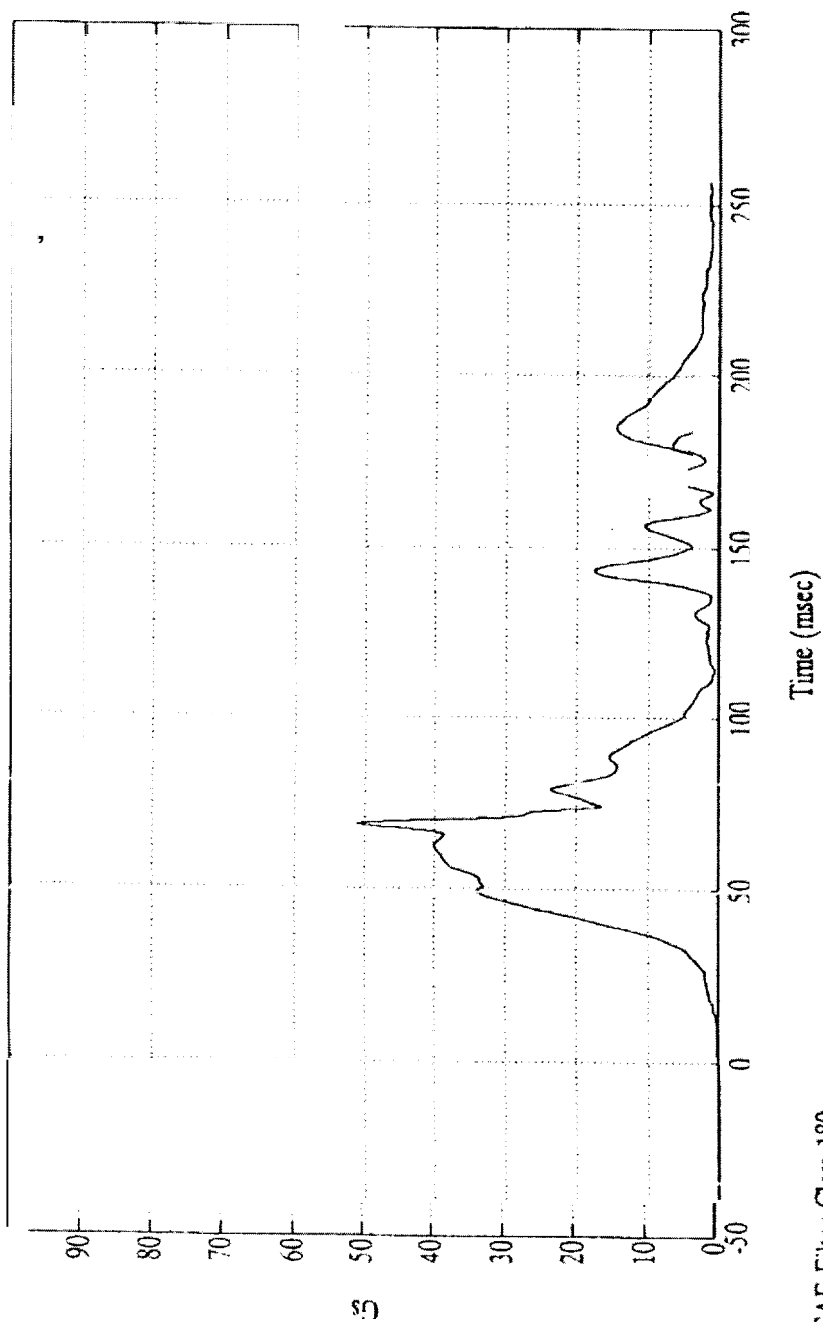


Figure A-14. Chest resultant acceleration time histories for Hybrid II and Hybrid III three-year-old dummies in Cosco Triad w/ LATCH

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Chest Resultant
Max = 51.19 Gs @ 68.87 msec
Min = .00 Gs @ -23.40 msec



SAE Filter Class 180

Figure A-15a. Chest resultant acceleration time history for Hybrid II three-year-old dummy in Century Breverra Classic w/ lap belt/top tether

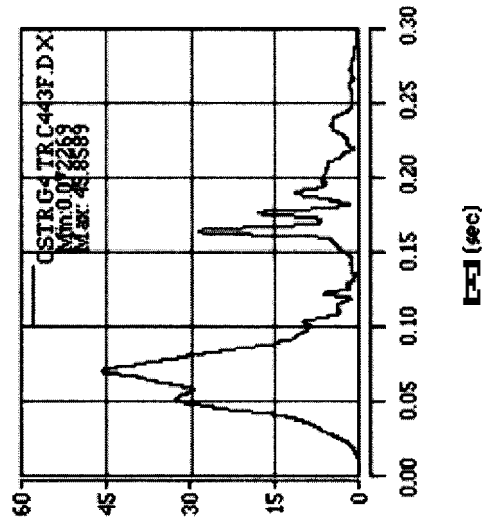
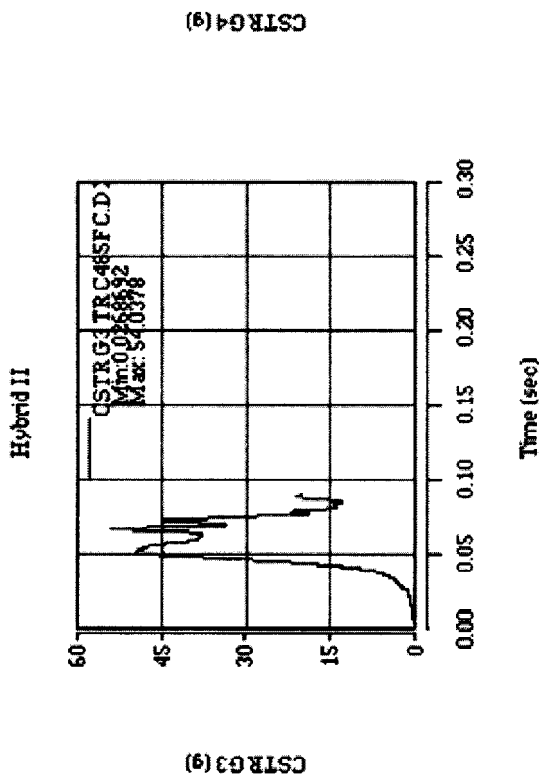
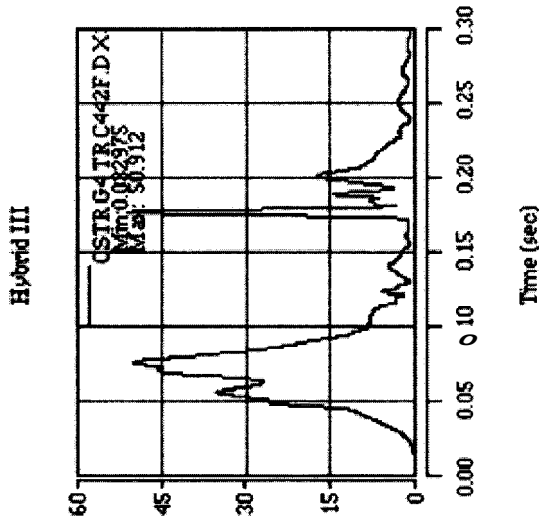
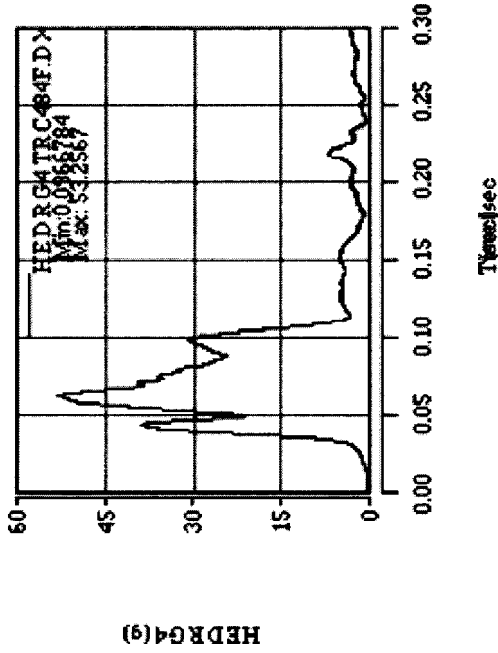


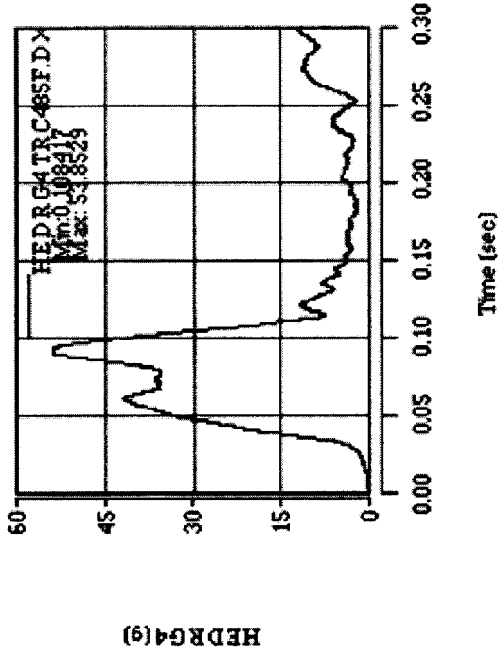
Figure A-15b. Chest resultant acceleration time histories for Hybrid II and Hybrid III three-year-old dummies in Century Breveira Classic w/ lap belt/top tether

CRABI-12 Dummy

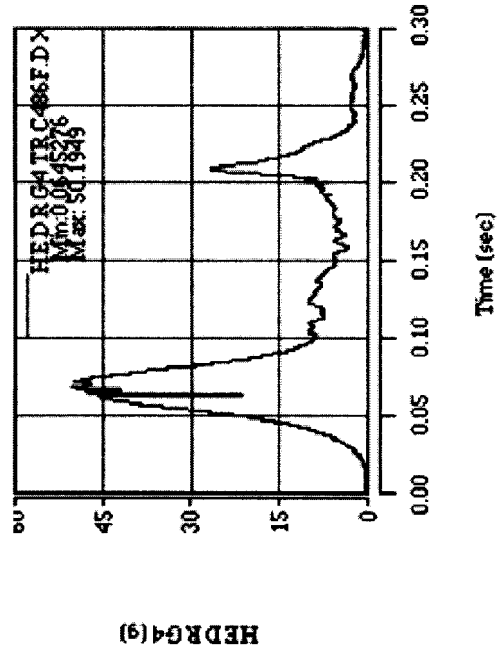
Evenflo On My Way (Rear)



Century SmartFit (Rear)



Bosco Touriva w/ether (Fwd)



Cosco Touriva w/ether (Fwd)

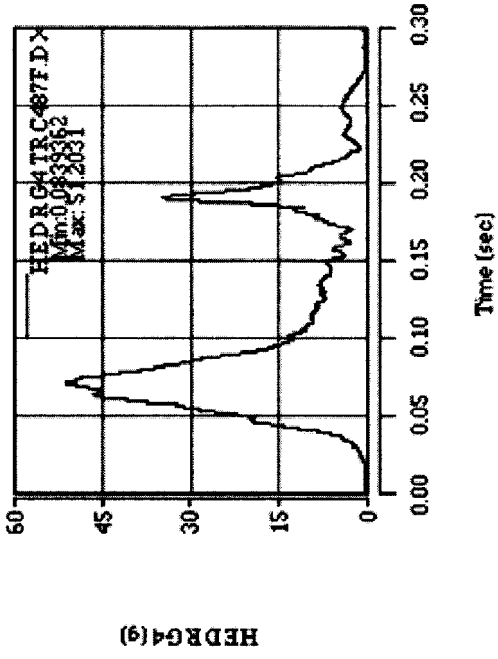
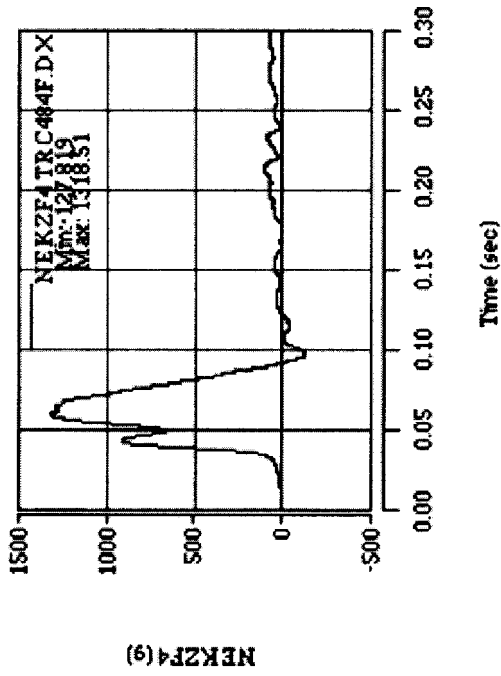
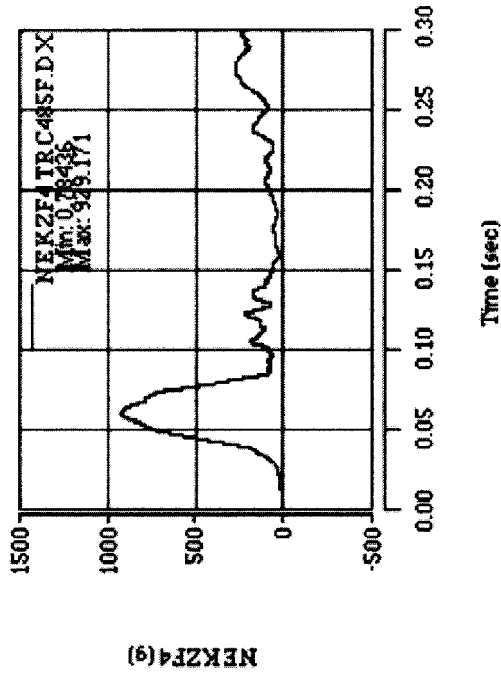


Figure A-16. CRABI-12 head resultant acceleration time histories for various seating configurations

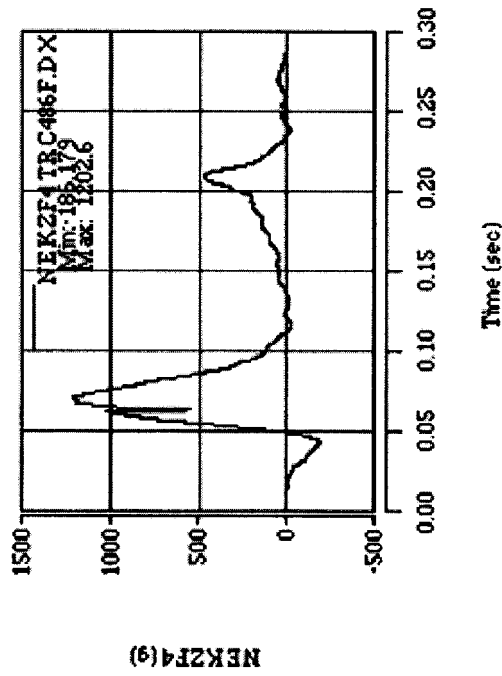
Evenflo On My Way (Rear)



Century SmartFit (Rear)



Cosco Touriva w/Tether (Fwd)



Cosco Touriva w/Tether (Fwd)

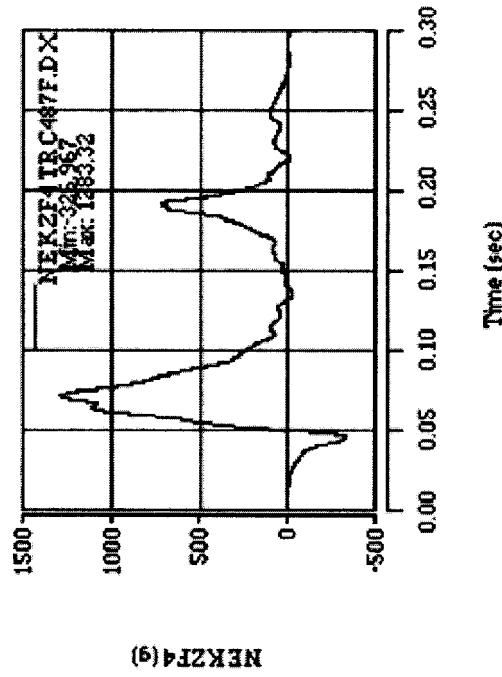
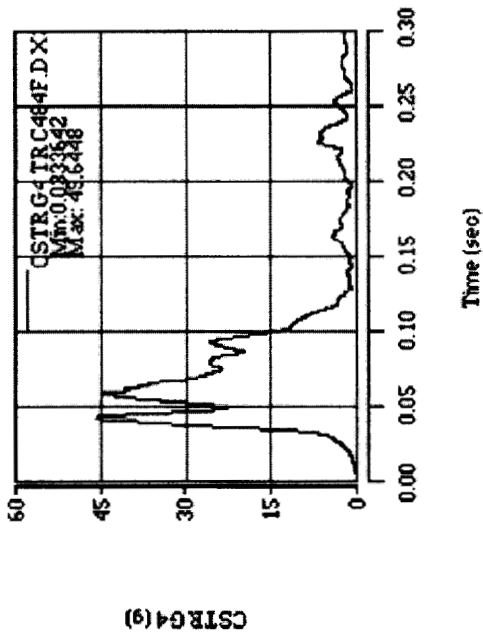
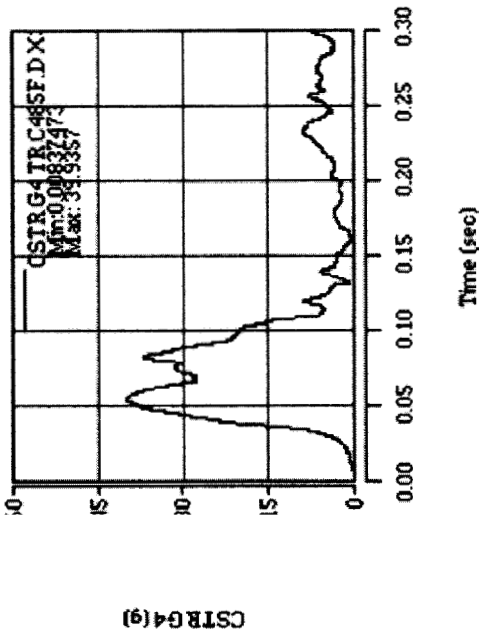


Figure A-17. CRABI-12 Upper Neck Z-force time histories for various seating configurations

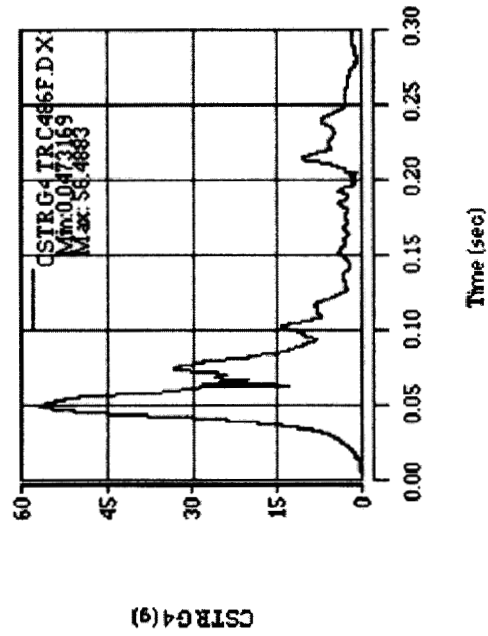
Evenflo On My Way (Rear)



Century SmartFit (Rear)



Cosco Touriva w/Tether (Fwd)



Cosco Touriva w/Tether (Fwd)

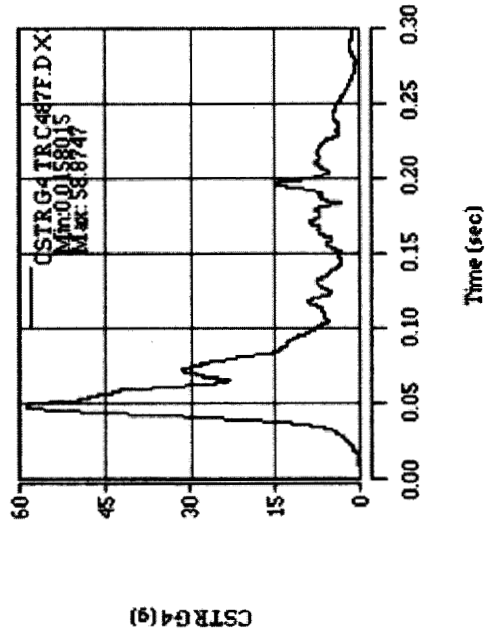
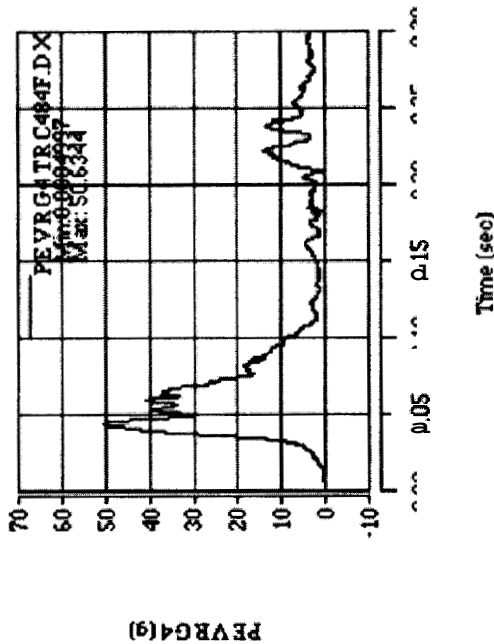
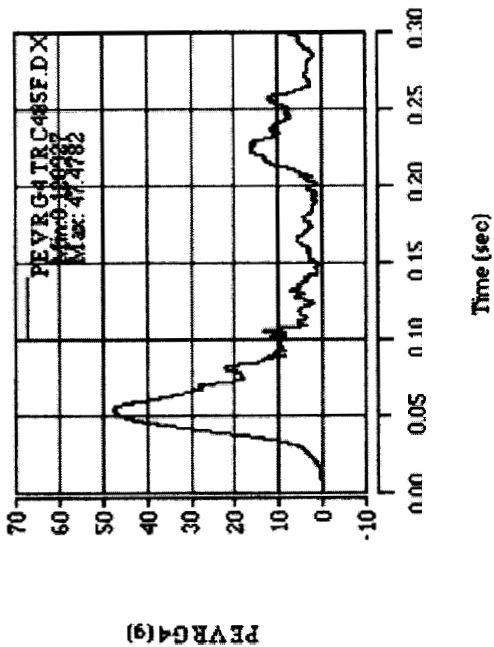


Figure A-18. CRABI-12 chest resultant acceleration time histories for various seating configurations

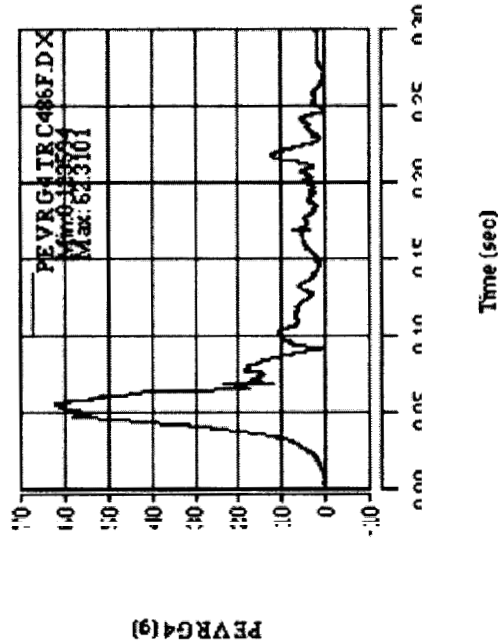
Evenflo On My Way (Rear)



Century SmartFit (Rear)



Cosco Touriva w/Tether (Fwd)



Cosco Touriva w/Tether (Fwd)

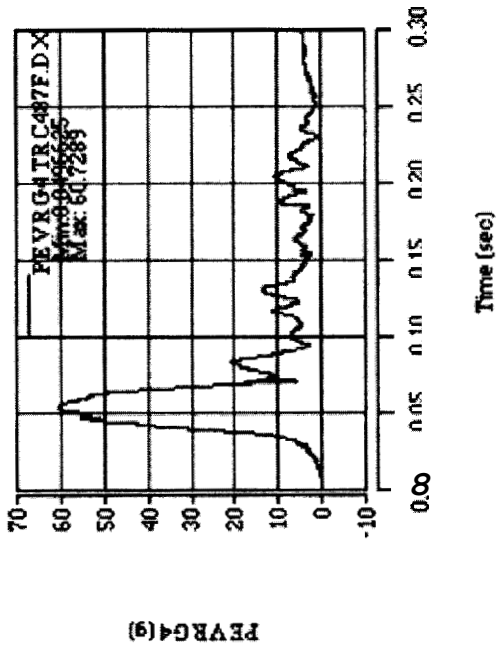


Figure A-19. CRABI-12 pelvis resultant acceleration time histories for various seating configurations