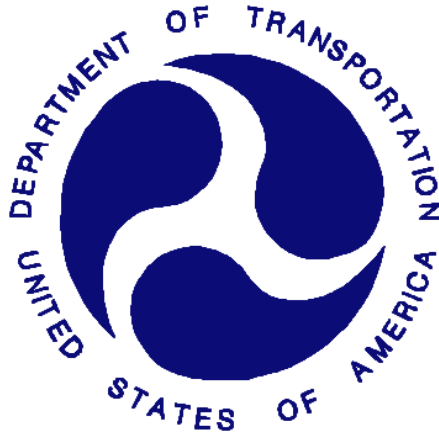


**Vehicle Research and Test Center  
1993 Cadillac DeVille into  
Rear of a 1996 Jeep Grand Cherokee Limited  
TRC Inc. Test Number: 131204**



**Prepared By:  
Transportation Research Center Inc.  
10820 State Route 347  
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**Final Report  
December 2013**

**Prepared For:  
Vehicle Research and Test Center  
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Test Performed By: John Shultz, Supervisor

Report Approved December 31, 2013 by:

A handwritten signature in cursive script that reads "Jeffery W. Sankey". The signature is written in black ink and is positioned above a horizontal line.

---

Jeffery W. Sankey  
Manager, Project Operations

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Section 1.0

Purpose and Test Procedure

## Purpose

This vehicle-to-vehicle rear impact test was conducted for the National Highway Traffic Safety Administration (NHTSA) and Vehicle Research and Test Center (VRTC) by Transportation Research Center Inc. (TRC Inc.).

The test mode was defined as the bullet vehicle moving at 56.3 km/h to impact the target vehicle moving at 0 km/h at an impact angle of 180 degrees. The purpose of this test was to evaluate the aggressiveness of the bullet vehicle, a 1993 Cadillac DeVille, and the vehicle response of the target vehicle, a 1996 Jeep Grand Cherokee Limited, in this vehicle-to-vehicle rear impact mode.

## Test Procedure

This test was conducted in accordance with VRTC instructions for a vehicle-to-vehicle rear impact test. Data was obtained relative to FMVSS 301, "Fuel System Integrity," performance.

The target vehicle, a 1996 Jeep Grand Cherokee Limited, was instrumented with six (6) accelerometers to measure longitudinal, lateral and vertical axis accelerations.

The bullet vehicle, a 1993 Cadillac DeVille, was instrumented with six (6) accelerometers to measure longitudinal, lateral and vertical axis accelerations. The vehicle's specified impact velocity range was 55.5 to 57.1 km/h.

The bullet vehicle impacted the rear of the target vehicle at an impact angle of 180 degrees. The intended impact point was the bullet vehicle's centerline aligned 381 millimeters left of the target vehicle's centerline.

One (1) Hybrid III 50<sup>th</sup> Male Ballast dummy was placed in the bullet vehicle's driver's seat. One (1) Hybrid III 50<sup>th</sup> Male Ballast dummy was placed in the target vehicle's driver's seat. Both dummies were restrained with seatbelts.

The twelve (12) data channels were digitally sampled and recorded at 12,500 samples per second and processed per SAE J211 March 1995.

The crash event was recorded by three (3) real-time panning motion picture cameras and nine (9) high-speed motion picture cameras.

The test summary data is presented in Section 2.0. The FMVSS 301 data is presented in Section 3.0. The camera and vehicle measurements are presented in Section 4.0. Appendix A contains the still photographic prints. Appendix B contains the vehicle data plots.

Section 2.0

Test Summary

### Test Results Summary

This 55.7 km/h 180° vehicle-to-vehicle rear impact test was conducted by TRC Inc. on December 4, 2013.

The target test vehicle, a 1996 Jeep Grand Cherokee Limited, was equipped with a 4.0-liter 6 cylinder engine, 3 speed automatic transmission, power steering, power brakes, and front airbags. The target vehicle's test weight was 1901.8 kg.

The bullet test vehicle, a 1993 Cadillac DeVille, was equipped with a 4.9-liter 8 cylinder transverse engine, 4 speed automatic transmission, power steering, power brakes, and driver's front airbags. The bullet vehicle's test weight was 1742.2 kg. The bullet vehicle's impact speed was 55.7 km/h.

### Data Acquisition Explanations

The target vehicle redundant CG Z-axis acceleration data channel recorded no valid data throughout the test event. This affected the resultant acceleration calculation.

Table 1 Crash Test Summary

Test mode:	Vehicle to Vehicle Rear Impact
Test date:	December 4, 2013
Test time:	11:38 AM
Ambient temperature:	10.1°C
Target vehicle year/make/ model/body style:	1996 Jeep/Grand Cherokee Limited/MPV
Target vehicle test weight:	1901.8 kg
Bullet vehicle year/make/ model/body style:	1993/Cadillac/DeVille/ Sedan
Bullet vehicle test weight:	1742.2 kg
Impact angle <sup>1</sup> :	180°
Impact velocity <sup>2</sup> :	Bullet vehicle = 55.7 km/h
Total number of data channels:	12
Number of cameras:	
High-speed:	9
Real-time:	3

<sup>1</sup> With respect to tow track centerline.

<sup>2</sup> Speed trap measurement ( $\pm$  .08 km/h accuracy)

Table 2 Target Vehicle General Test and Vehicle Parameter Data

Vehicle year/make/  
model/body style: 1996 Jeep/Grand Cherokee Limited/MPV

VIN: 1J4EZ78S9TC104655

Model year: 1996

Body style: MPV

Color: Green

Engine data:  
Cylinders: 6  
Displacement 4.0 liters  
Type: Straight  
Placement: Longitudinal

Transmission data: 3 speed,    manual, X automatic, X overdrive  
Final drive:    FWD,    RWD, X 4WD

Date vehicle received: 12/2/2013

Odometer reading: 142,778

Dealer's name Customer Supplied

Accessories:

Power steering	Yes	Automatic transmission	Yes
Power brakes	Yes	Automatic speed control	Yes
Power seats	Yes	Tilting steering wheel	Yes
Power windows	Yes	Telescoping steering wheel	No
Tinted glass	Yes	Air conditioning	Yes
Radio	Yes	Anti-skid brake	Yes
Clock	Yes	Rear window defroster	Yes
Other	None	Power door locks	Yes

Certification data from vehicle's label:

Vehicle manufactured by: Chrysler Corporation

Date of manufacture: 7/95

VIN: 1J4EZ78S9TC104655

GVWR: 5300 lbs. (2405 kg)

GAWR: Front: 2750 lbs. (1248 kg)  
Rear: 2950 lbs. (1339 kg)

Table 2 Target Vehicle General Test and Vehicle Parameter Data, Continued

Tires on vehicle (mfr., line, size):

LF	Kumho, KH16, 225/70R16
RF	Hankook, Optimo, 225/70R16
LR	Goodyear, Integrity, 225/70R16
RR	Goodyear, Integrity, 225/70R16

Tire pressure with maximum capacity vehicle load:

Front:	44 psi (300 kPa)
Rear:	44 psi (300 kPa)

Spare tire (mfr., line, size): Goodyear, Unknown, P245/70R15

Type of seats:

Front	Bucket
Rear	Split Bench

Maximum width: 1810 mm

Wheelbase: 2680 mm

Location of "Recommended Tire Pressure" label:

Left B-Pillar

Data from vehicle's "Recommended Tire Pressure" label:

Recommended tire size:	P255/70R16
Recommended cold tire pressure:	Front: 36 psi (N/A kPa) Rear: 36 psi (N/A kPa)
Seating capacity:	Front: 2 Mid: 0 Rear: 3 Total: 5
Vehicle capacity weight:	N/A lbs. (N/A kg)
Rated cargo/luggage weight:	N/A lbs. (N/A kg)

Test vehicle attitude:

Pre-test attitude:	LF 763 mm;	RF 787 mm;	LR 797 mm;	RR 815 mm
Post-test attitude:	LF 770 mm;	RF 775 mm;	LR 792 mm;	RR 742 mm

Table 2 Target Vehicle General Test and Vehicle Parameter Data Continued

Weight of test vehicle with required dummies and cargo weight:

Right front	515.8 kg	Right rear	400.0 kg
Left front	550.6 kg	Left rear	435.4 kg
Total front weight	1066.4 kg	(56.1% of total vehicle weight)	
Total rear weight	835.4 kg	(43.9% of total vehicle weight)	
Total test weight	1901.8 kg		

Weight of ballast secured in vehicle: 0 kg

Components removed to meet target test weight: None

Location of Vehicle's CG: 1177 mm rearward of front wheel centerline

Fuel System Data:

Usable fuel system capacity N/A liters (from owner's manual)

Actual test volume: 68.5 liters

Table 3 Bullet Vehicle General Test and Vehicle Parameter Data

Vehicle year/make/ model/body style:	1993/Cadillac/DeVille/Sedan
VIN:	1G6CD5389P4207889
Model year:	1993
Body style:	Sedan
Color:	Red
Engine data:	
Cylinders:	8
Displacement	4.9 liters
Type:	V
Placement:	Transverse
Transmission data:	<u>4</u> speed, <input type="checkbox"/> manual, <input checked="" type="checkbox"/> automatic, <input checked="" type="checkbox"/> overdrive
Final drive:	<input checked="" type="checkbox"/> FWD, <input type="checkbox"/> RWD, <input type="checkbox"/> 4WD
Date vehicle received:	12/2/2013
Odometer reading:	127,715
Dealer's name	Customer Supplied

Accessories:

Power steering	Yes	Automatic transmission	Yes
Power brakes	Yes	Automatic speed control	Yes
Power seats	Yes	Tilting steering wheel	Yes
Power windows	Yes	Telescoping steering wheel	No
Tinted glass	Yes	Air conditioning	Yes
Radio	Yes	Anti-skid brake	No
Clock	Yes	Rear window defroster	Yes
Other	None	Power door locks	Yes

Certification data from vehicle's label:

Vehicle manufactured by:	General Motors Corporation
Date of manufacture:	8/92
VIN:	1G6CD5389P4207889
GVWR:	4682 lbs. (2126 kg)
GAWR: Front:	2623 lbs. (1190 kg)
Rear:	2063 lbs. (936 kg)

Table 3 Bullet Vehicle General Test and Vehicle Parameter Data, Continued

Tires on vehicle (mfr., line, size): Hurcules, Tour 4.0, 205/70R15

Tire pressure with maximum capacity vehicle load:

Front: 44 psi (300 kPa)

Rear: 44 psi (300 kPa)

Spare tire (mfr., line, size): Uniroyal, Temporary, T125/70D15

Type of seats:

Front Bucket

Rear Bench

Maximum width: 1860 mm

Wheelbase: 2885 mm

Location of "Recommended Tire Pressure" label:

Left B-Pillar

Data from vehicle's "Recommended Tire Pressure" label:

Recommended tire size: P205/70R15

Recommended cold tire pressure: Front: 30 psi (210 kPa)

Rear: 30 psi (210 kPa)

Seating capacity: Front: 3

Mid: 0

Rear: 3

Total: 6

Vehicle capacity weight: 1027 lbs. (466 kg)

Rated cargo/luggage weight: N/A lbs. (N/A kg)

Test vehicle attitude:

Pre-test attitude: LF 645 mm; RF 711 mm; LR 655 mm; RR 669 mm

Post-test attitude: LF 691 mm; RF 657 mm; LR 677 mm; RR 676 mm

Table 3 Bullet Vehicle General Test and Vehicle Parameter Data, Continued

Weight of test vehicle with required dummies and cargo weight:

Right front	510.2 kg	Right rear	342.4 kg
Left front	547.4 kg	Left rear	342.2 kg
Total front weight	1057.6 kg	(60.7% of total vehicle weight)	
Total rear weight	684.6 kg	(39.3% of total vehicle weight)	
Total test weight	1742.2 kg		

Weight of ballast secured in vehicle: 0 kg

Components removed to meet target test weight: None

Location of Vehicle's CG: 1134 mm rearward of front wheel centerline

Fuel System Data:

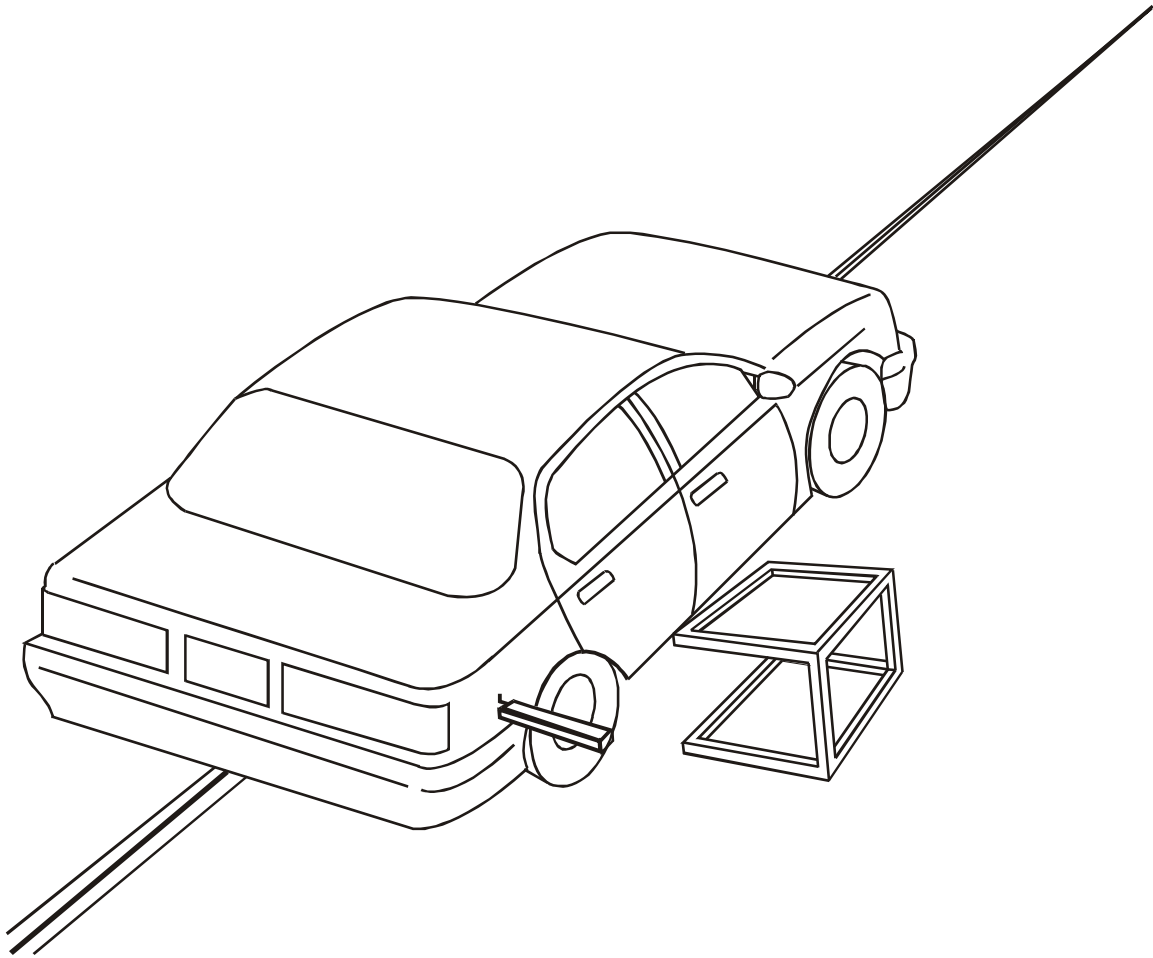
Usable fuel system capacity N/A liters (from owner's manual)

Actual test volume: 70.4 liters

Table 4 Post-Impact Data

Test number:	131204
Test date:	12/4/2013
Test time:	11:38 AM
Test type:	Vehicle to Vehicle Rear Impact
Impact angle:	180°
Ambient temperature at impact area:	10.1°C
Impact velocity:	
Target vehicle:	0 km/h
Bullet vehicle:	55.7 km/h
Required impact velocity range:	
Bullet vehicle:	55.5 to 57.1 km/h
Distance from each vehicle to intended impact point:	
Entering velocity trap:	660 mm
Exiting velocity trap:	50 mm, approximately

Figure 1 Impact Velocity Measurement System



The vane clears the final emitter/receiver pair approximately 50 millimeters before impact.

The emitter/receiver pairs have 610-millimeter spacing.

Table 5 Target Vehicle Accelerometer Data Summary

Accel. No.	Location		Positive Direction		Negative Direction	
			Max. (g)	Time (ms)	Max. (g)	Time (ms)
1	Vehicle Center of Gravity	X	12.2	110.1	-3.1	37.3
		Y	12.3	21.0	-8.3	42.0
		Z	12.5	25.4	-12.0	30.6
		R	16.5	30.3	---	---
2	Vehicle Center of Gravity Redundant	X	12.5	110.1	-3.3	37.4
		Y	12.6	21.0	-8.4	42.0
		Z <sup>1</sup>	---	---	---	---
		R <sup>1</sup>	13.6	109.8	---	---

Reference:           X: + Forward From Rear Bumper  
                           Y: + Rightward From Vehicle Centerline  
                           Z: + Downward From Ground Level

<sup>1</sup> See Data Acquisition Explanations

Table 6 Bullet Vehicle Accelerometer Data Summary

Accel. No.	Location		Positive Direction		Negative Direction	
			Max. (g)	Time (ms)	Max. (g)	Time (ms)
1	Vehicle Center of Gravity	X	0.2	209.4	-15.6	15.8
		Y	1.7	19.8	-2.9	34.1
		Z	23.9	97.3	-26.3	28.3
		R	28.2	28.2	---	---
2	Vehicle Center of Gravity Redundant	X	0.2	252.1	-15.7	15.8
		Y	3.9	96.8	-2.5	31.4
		Z	23.6	97.1	-23.4	28.6
		R	24.9	28.6	---	---

Reference:           X: + Forward From Rear Bumper  
                           Y: + Rightward From Vehicle Centerline  
                           Z: + Downward From Ground Level

Table 7 Target Vehicle Measurements

1996 Jeep Grand Cherokee Limited

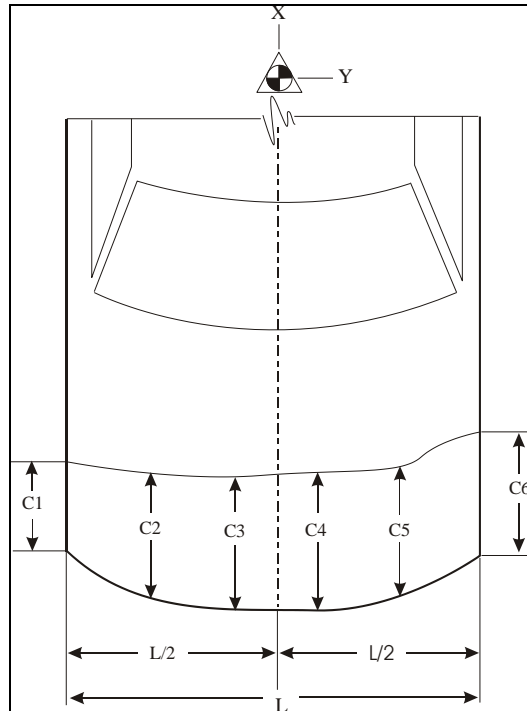
Test Number: 131204

No.	Type of measurement	Pre-Test	Post-Test	Difference
X1	Total Length of Vehicle at Centerline	4468	4180	288
X2	Front Surface of Vehicle to Front of Engine Block	561	573	-12
X3	Front Surface of Vehicle to Firewall	1078	1090	-12
X4	Front Surface of Vehicle to Upper Leading Edge of Right Door	1413	1428	-15
X5	Front Surface of Vehicle to Upper Leading Edge of Left Door	1411	1427	-16
X6	Front Surface of Vehicle to Lower Leading Edge of Right Door	1448	1440	8
X7	Front Surface of Vehicle to Lower Leading Edge of Left Door	1443	1446	-3
X8	Front Surface of Vehicle to Upper Trailing Edge of Right Door	2430	2445	-15
X9	Front Surface of Vehicle to Upper Trailing Edge of Left Door	2431	2450	-19
X10	Front Surface of Vehicle to Lower Trailing Edge of Right Door	2455	2446	9
X11	Front Surface of Vehicle to Lower Trailing Edge of Left Door	2457	2462	-5
X12	Front Surface of Vehicle to Bottom of " A " Post on Right Side	1448	1460	-12
X13	Front Surface of Vehicle to Bottom of " A " Post on Left Side	1448	--- <sup>1</sup>	--- <sup>1</sup>
X14	Front Surface of Vehicle to Firewall-Right Side	1068	1080	-12
X15	Front Surface of Vehicle to Firewall-Left Side	1108	1120	-12
X16	Rear Surface of Vehicle to Steering Wheel Center	1909	1930	-21
X17	Center of Steering Column to " A " Post	292	--- <sup>1</sup>	--- <sup>1</sup>
X18	Center of Steering Column to Headliner	435	450	-15
X19	Front Surface of Vehicle to Right Side of Rear Bumper	4428	4227	201
X20	Front Surface of Vehicle to Left Side of Rear Bumper	4423	4065	358
X21	Length of Engine Block	700	700	0

All measurements are in millimeters.

<sup>1</sup> Measurement point missing post-test.

Figure 2 Target Vehicle Crush



Notes: L is pre-test length of contact surface.  
 C1 through C6 are spaced equally apart.  
 CL is vehicle centerline.

Vehicle: 1996 Jeep Grand Cherokee Limited

	Pre-test	Post-test	Crush
L	1524	N/A	N/A
C1	4423	4065	358
C2	4483	4105	378
C3	4468	4155	313
CL	4468	4180	288
C4	4468	4195	273
C5	4485	4232	253
C6	4428	4227	201

All measurements in millimeters.

Table 8 Bullet Vehicle Measurements

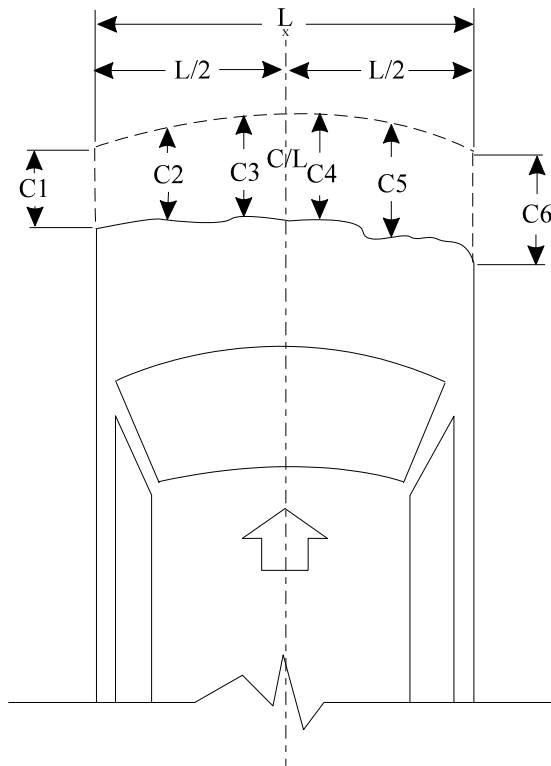
1993 Cadillac DeVille

Test Number: 131204

No.	Type of measurement	Pre-Test	Post-Test	Difference
X1	Total Length of Vehicle at Centerline	5195	5043	152
X2	Rear Surface of Vehicle to Front of Engine Block	4630	4583	47
X3	Rear Surface of Vehicle to Firewall	3883	3888	-5
X4	Rear Surface of Vehicle to Upper Leading Edge of Right Door	3517	3515	2
X5	Rear Surface of Vehicle to Upper Leading Edge of Left Door	3515	3515	0
X6	Rear Surface of Vehicle to Lower Leading Edge of Right Door	3491	3490	1
X7	Rear Surface of Vehicle to Lower Leading Edge of Left Door	3495	3500	-5
X8	Rear Surface of Vehicle to Upper Trailing Edge of Right Door	2505	2505	0
X9	Rear Surface of Vehicle to Upper Trailing Edge of Left Door	2505	2505	0
X10	Rear Surface of Vehicle to Lower Trailing Edge of Right Door	2505	2500	5
X11	Rear Surface of Vehicle to Lower Trailing Edge of Left Door	2507	2510	-3
X12	Rear Surface of Vehicle to Bottom of " A " Post on Right Side	3500	3490	10
X13	Rear Surface of Vehicle to Bottom of " A " Post on Left Side	3500	3500	0
X14	Rear Surface of Vehicle to Firewall-Right Side	3820	3771	49
X15	Rear Surface of Vehicle to Firewall-Left Side	3820	3831	-11
X16	Rear Surface of Vehicle to Steering Wheel Center	3049	3045	4
X17	Center of Steering Column to " A " Post	325	330	-5
X18	Center of Steering Column to Headliner	430	435	-5
X19	Rear Surface of Vehicle to Right Side of Front Bumper	5120	4895	225
X20	Rear Surface of Vehicle to Left Side of Front Bumper	5120	5156	-36
X21	Length of Engine Block	600	600	0
	Left Front Overhang	1095	1046	49
	Right Front Overhang	1095	800	295
X26	Firewall to Engine or Transaxle	340	340	0
X27	Vertical Distance from Door Sill to Centerline of Steering Column	525	525	0
X28	Left Wheelbase	2885	2895	-10
X28	Right Wheelbase	2885	2880	5
X29	Maximum Width	1860	1860	0
X30	Rear Surface of Vehicle to Engine Bottom Target	4325	4338	-13
X31	Rear Surface of Vehicle to Occupant Compartment Bottom Targets	2838	2831	7
X32	Rear Surface of Vehicle to Front Bumper Bottom Target	5105	4953	152
X33	Rear Surface of Vehicle to Frame Crossmember Bottom Target	4464	4478	-14
RD	Rear Surface of Vehicle to Right Side of Dash Panel	3315	3315	0
CD	Rear Surface of Vehicle to Center of Dash Panel	3343	3345	-2
LD	Rear Surface of Vehicle to Left Side of Dash Panel	3325	3325	0

All measurements are in millimeters.

**Figure 3 Bullet Vehicle Crush**



Notes: L is pre-test length of contact surface.  
 C1 through C6 are spaced equally apart.  
 CL is vehicle centerline.

Vehicle: 1993 Cadillac DeVille

	Pre-test	Post-test	Crush
L	1524	N/A	N/A
C1	5120	5156	-36
C2	5138	5105	33
C3	5175	5078	97
CL	5195	5043	152
C4	5170	5010	160
C5	5128	4915	213
C6	5120	4895	225

All measurements are in millimeters.

Section 3.0

FMVSS 301 Data

Table 9 Target Vehicle Fuel System Data

Vehicle year/make/ model/body style:	1996/Jeep/Grand Cherokee Limited/MPV
Actual test volume:	68.5 liters
Test fluid type:	Stoddard
Specific gravity:	0.764
Kinematic viscosity:	0.99 centistoke
Test fluid color:	Purple
Type of fuel pump:	Electric
Did electric fuel pump operate with ignition switch "on" and the engine not operating.	Yes
Details of fuel system:	The fuel tank is located behind the rear axle. The fuel filler neck enters the top left side of the fuel tank. The fuel filler cap is located on the left rear quarter panel. The fuel lines run along the inside of the left frame rail.

Table 10 Target Vehicle FMVSS 301 Post-Impact Test Data

Test date: 12/4/2013  
Vehicle year/make/  
model/body style: 1996/Jeep/Grand Cherokee Limited/MPV

Test requirements:

Test vehicle fuel tank filled was filled with 68.5 liters of Stoddard and had an electric fuel pump operating (if it will operate without engine operation). Part 572 test dummies located at each front designated seating position.

Test vehicle impact type:

- Frontal (30 mph)
- Oblique (30 mph) with  barrier face first contacting (driver's/passenger's) side
- Rear vehicle to vehicle impact
- Lateral moving barrier (20 mph)

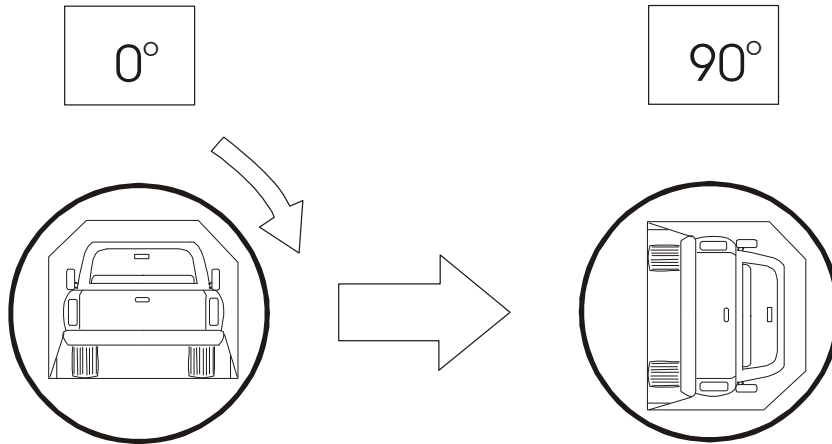
Fuel system fluid spillage measurements:

	<u>Test Results</u>	<u>Maximum Allowable</u>
1. From impact until vehicle motion ceases	None	28 g
2. 5-minute period after vehicle motion ceases	None	142 g
3. Next 25 minutes after 5-minute period	None	28 g/minute

Fuel system fluid spillage location(s): None

Figure 4 Target Vehicle FMVSS 301 Static Rollover Test Data

Test phase



Static rollover machine rotation time information: (specified range is 1-3 minutes)

Time required for machine to rotate 90° = 2 minutes, 0 seconds  
 FMVSS 301 position hold time = 5 minutes, 0 seconds  
 Total = 7 minutes, 0 seconds  
 Next whole minute interval = 7 minutes

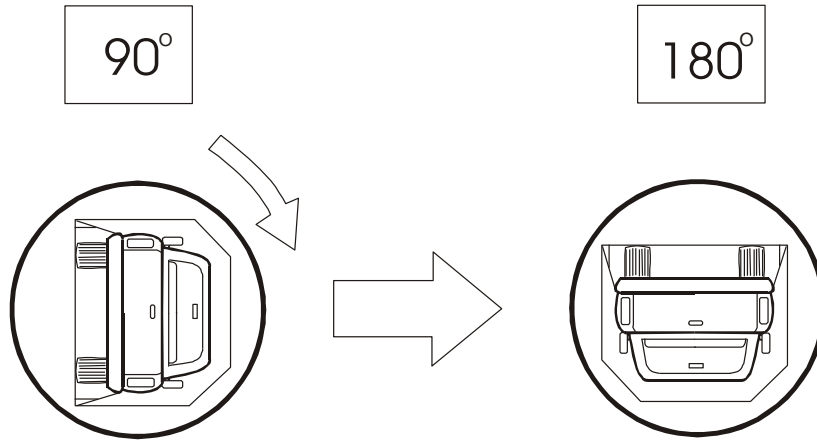
Fuel system fluid spillage measurements:

<u>0° to 90° rotation (fuel filler cap down)</u>		Test Results	Maximum Allowable
1.	First five minutes from onset of rotation	0g	142 g
2.	Sixth minute from onset of rotation	0g	28 g
3.	Seventh minute from onset of rotation	0g	28 g

Fuel system fluid spillage location(s): None

Figure 4 Target Vehicle FMVSS 301 Static Rollover Test Data, Continued

Test phase



Static rollover machine rotation time information: (specified range is 1-3 minutes)

Time required for machine to rotate 90°	=	2	minutes,	0	seconds
FMVSS 301 position hold time	=	5	minutes,	0	seconds
Total	=	7	minutes,	0	seconds
Next whole minute interval	=	14	minutes		

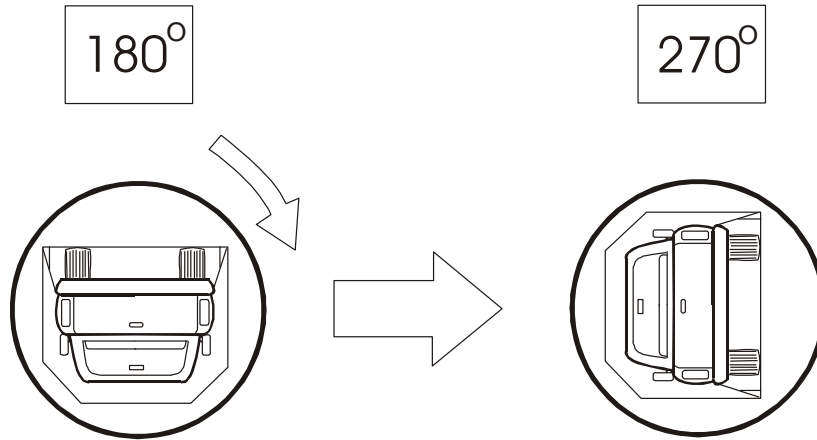
Fuel system fluid spillage measurements:

<u>90° to 180° rotation</u>	Test Results	Maximum Allowable
1. First five minutes from onset of rotation	0g	142 g
2. Sixth minute from onset of rotation	0g	28 g
3. Seventh minute from onset of rotation	0g	28 g

Fuel system fluid spillage location(s): None

Figure 4 Target Vehicle FMVSS 301 Static Rollover Test Data, Continued

Test phase



Static rollover machine rotation time information: (specified range is 1-3 minutes)

Time required for machine to rotate 90°	=	2	minutes,	0	seconds
FMVSS 301 position hold time	=	5	minutes,	0	seconds
Total	=	7	minutes,	0	seconds
Next whole minute interval	=	21	minutes		

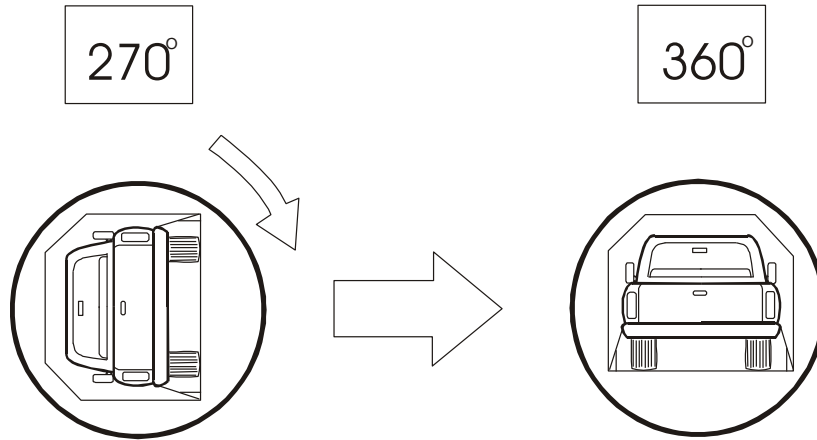
Fuel system fluid spillage measurements:

<u>180 to 270° rotation</u>	Test Results	Maximum Allowable
1. First five minutes from onset of rotation	0g	142 g
2. Sixth minute from onset of rotation	0g	28 g
3. Seventh minute from onset of rotation	0g	28 g

Fuel system fluid spillage location(s): None

Figure 4 Target Vehicle FMVSS 301 Static Rollover Test Data, Continued

Test phase



Static rollover machine rotation time information: (specified range is 1-3 minutes)

Time required for machine to rotate 90°	=	2	minutes,	0	seconds
FMVSS 301 position hold time	=	5	minutes,	0	seconds
Total	=	7	minutes,	0	seconds
Next whole minute interval	=	28	minutes		

Fuel system fluid spillage measurements:

<u>270° to 360° rotation</u>	Test Results	Maximum Allowable
1. First five minutes from onset of rotation	0g	142 g
2. Sixth minute from onset of rotation	0g	28 g
3. Seventh minute from onset of rotation	0g	28 g

Fuel system fluid spillage location(s): None

Section 4.0

Camera Information

Figure 5 Camera Positions

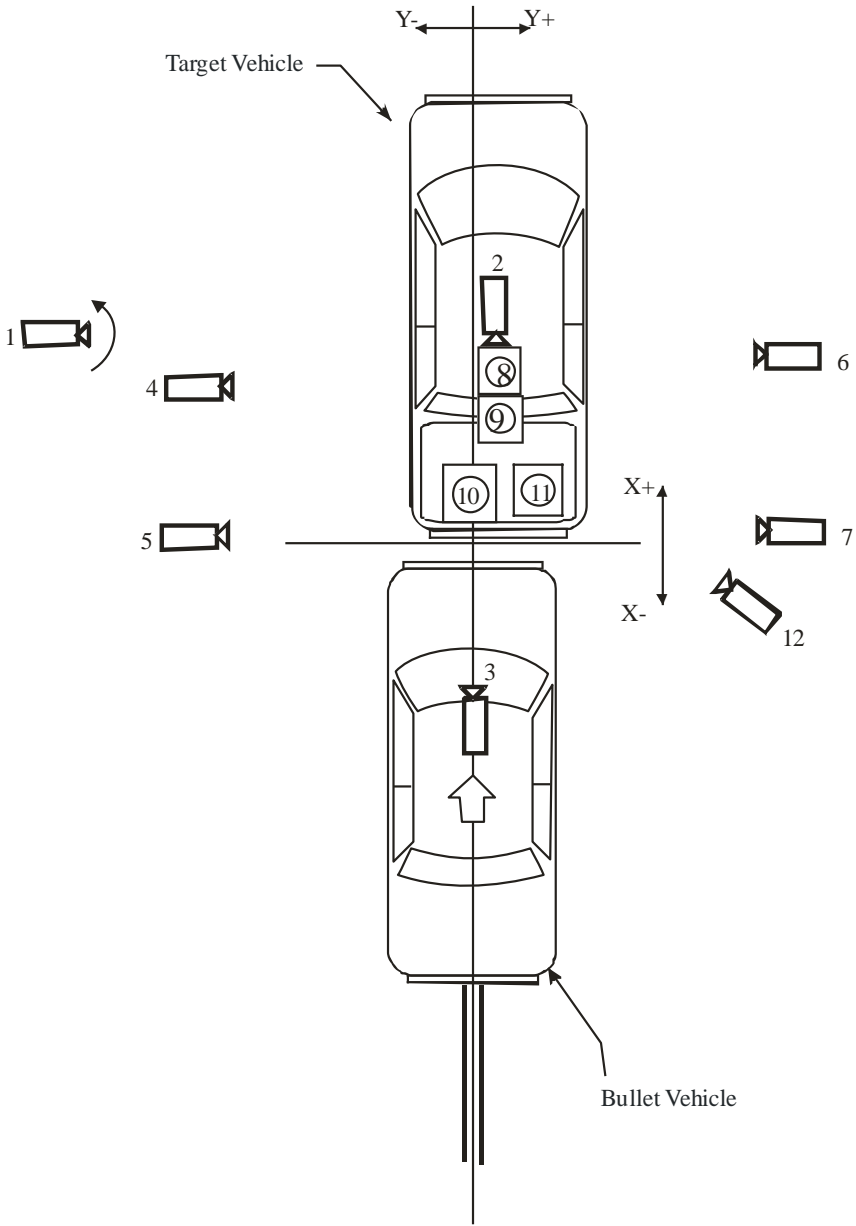


Table 11 Camera Information

Camera Number	Location	Location, mm			Angle (deg.)	Lens (mm)	Speed (fps)
		X	Y	Z			
1	Realtime Panning	N/A	N/A	N/A	N/A	Zoom	30
2	Realtime onboard target vehicle	N/A	N/A	N/A	N/A	Zoom	30
3	Realtime onboard bullet vehicle	N/A	N/A	N/A	N/A	Zoom	30
4	Left side target vehicle	1265	-6147	-1336	-1.5°	8.5	1000
5	Left side impact	0	-6325	-858	-1.1°	16	1000
6	Right side target vehicle	1490	6706	-1280	-3.4°	8.5	1000
7	Right side impact	460	6584	-964	0.1°	16	1000
8	Overhead	1040	710	-5334	N/A	8.5	1000
9	Pit wide	931	110	2907	85.3°	16	1000
10	Pit medium	575	210	2699	88.1°	25	N/A <sup>1</sup>
11	Pit tight	471	-50	2990	89.1°	75	N/A <sup>1</sup>
12	Right ground level tight impact	-2038	3353	-65	10.2°	50	N/A <sup>1</sup>

+X: Forward (referenced to Target) from impact point  
 +Y: Rightward (referenced to Target) from impact point  
 +Z: Downward from ground level

<sup>1</sup> Video camera views could not be downloaded after the impact.

Appendix A

Photographs



**Figure A-1 Pre-Test Target Vehicle Frontal View**



**Figure A-2 Post-Test Target Vehicle Frontal View**



**Figure A-3 Pre-Test Target Vehicle Left Front 3/4 View**



**Figure A-4 Post-Test Target Vehicle Left Front 3/4 View**



**Figure A-5 Pre-Test Target Vehicle Left Side View**



**Figure A-6 Post-Test Target Vehicle Left Side View**



**Figure A-7 Pre-Test Target Vehicle Rear View**



**Figure A-8 Post-Test Target Vehicle Rear View**



**Figure A-9 Pre-Test Target Vehicle Right Rear 3/4 View**



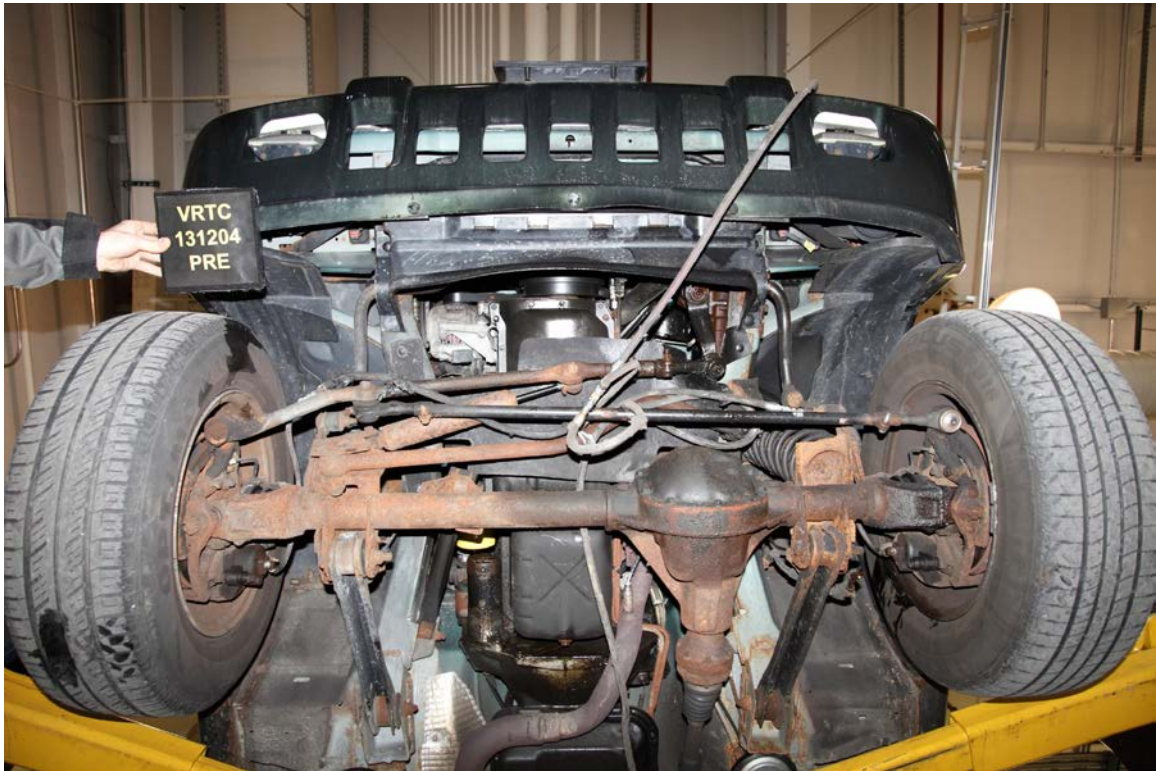
**Figure A-10 Post-Test Target Vehicle Right Rear 3/4 View**



Figure A-11 Pre-Test Target Vehicle Right Side View



Figure A-12 Post-Test Target Vehicle Right Side View



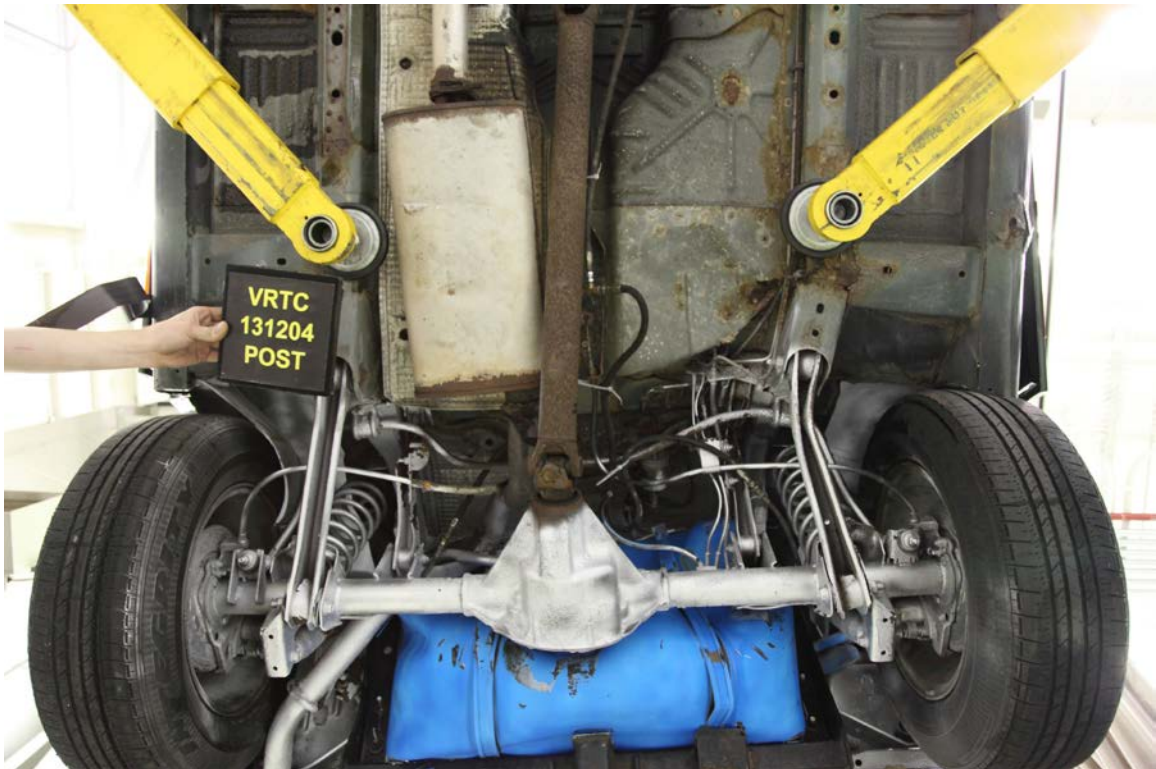
**Figure A-13 Pre-Test Target Vehicle Front Underbody View**



**Figure A-14 Post-Test Target Vehicle Front Underbody View**



**Figure A-15 Pre-Test Target Vehicle Rear Underbody View**



**Figure A-16 Post-Test Target Vehicle Rear Underbody View**



**Figure A-17 Pre-Test Target Vehicle Overhead View**

**Photo Not Available**

**Figure A-18 Post-Test Target Vehicle Overhead View**



Figure A-19 Pre-Test Target Vehicle Fuel Tank Close-up View

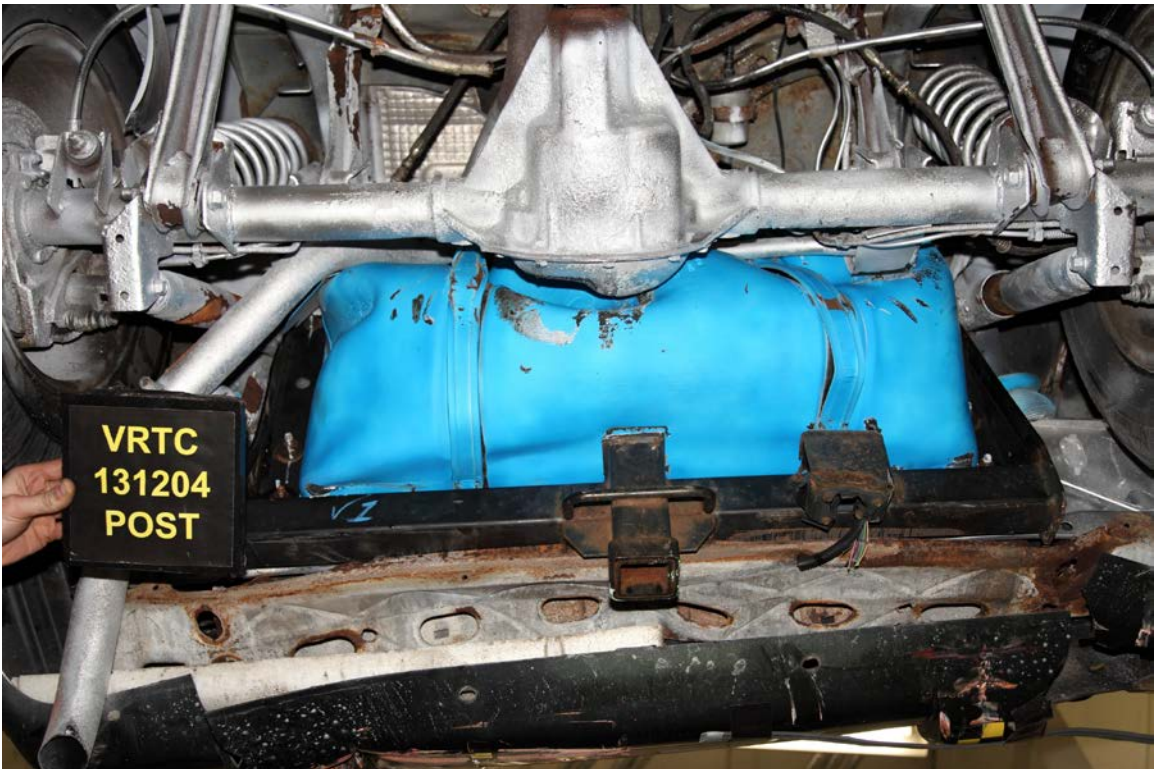


Figure A-20 Post-Test Target Vehicle Fuel Tank Close-up View



**Figure A-21 Pre-Test Target Vehicle Fuel Line Close-up View**



**Figure A-22 Pre-Test Target Vehicle Fuel Filler Close-up View**



**Figure A-23 Post-Test Target Vehicle Fuel Filler Close-up – View 1**



**Figure A-24 Post-Test Target Vehicle Fuel Filler Close-up – View 2**



Figure A-25 Pre-Test Target Vehicle Fuel Cap View



Figure A-26 Post-Test Target Vehicle Fuel Cap View



**Figure A-27 Close-Up View of Target Certification Label**

**Intentionally Left Blank**



**Figure A-28 Pre-Test Bullet Vehicle Frontal View**



**Figure A-29 Post-Test Bullet Vehicle Frontal View**



Figure A-30 Pre-Test Bullet Vehicle Left Front 3/4 View



Figure A-31 Post-Test Bullet Vehicle Left Front 3/4 View



**Figure A-32 Pre-Test Bullet Vehicle Left Side View**



**Figure A-33 Post-Test Bullet Vehicle Left Side View**



**Figure A-34 Pre-Test Bullet Vehicle Rear View**



**Figure A-35 Post-Test Bullet Vehicle Rear View**



**Figure A-36 Pre-Test Bullet Vehicle Right Rear 3/4 View**



**Figure A-37 Post-Test Bullet Vehicle Right Rear 3/4 View**



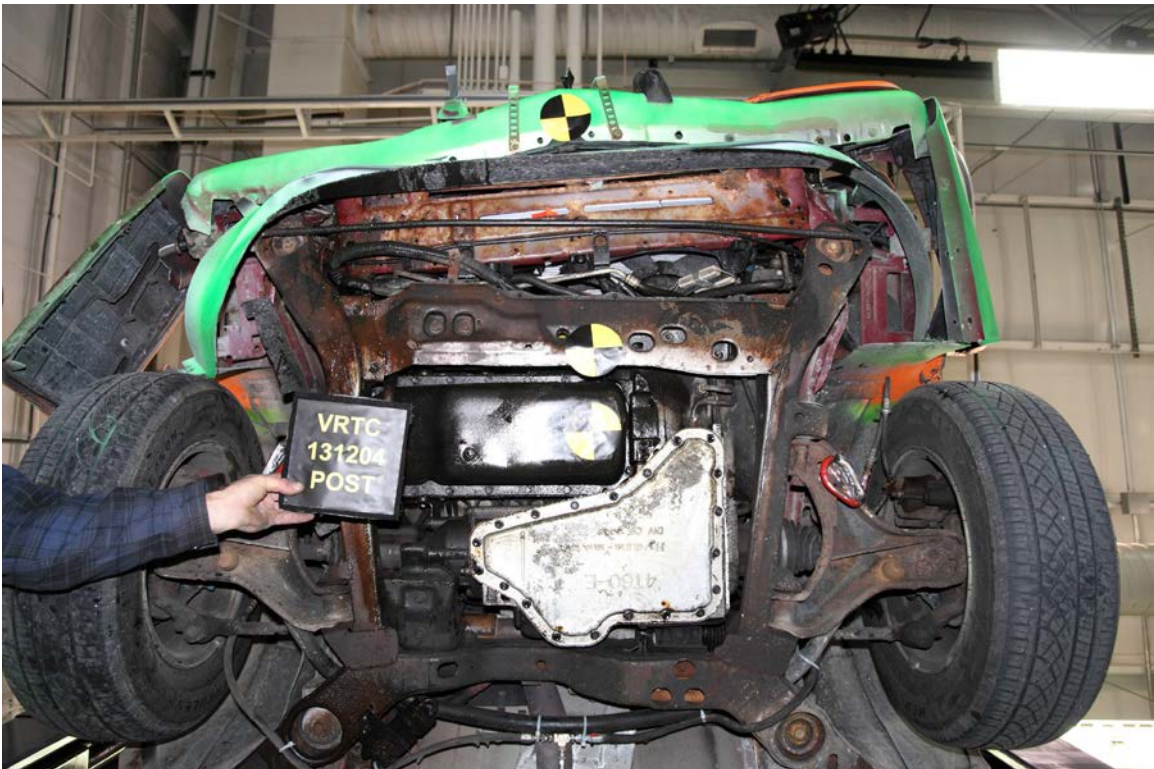
Figure A-38 Pre-Test Bullet Vehicle Right Side View



Figure A-39 Post-Test Bullet Vehicle Right Side View



**Figure A-40 Pre-Test Bullet Vehicle Front Underbody View**



**Figure A-41 Post-Test Bullet Vehicle Front Underbody View**



**Figure A-42 Pre-Test Bullet Vehicle Rear Underbody View**



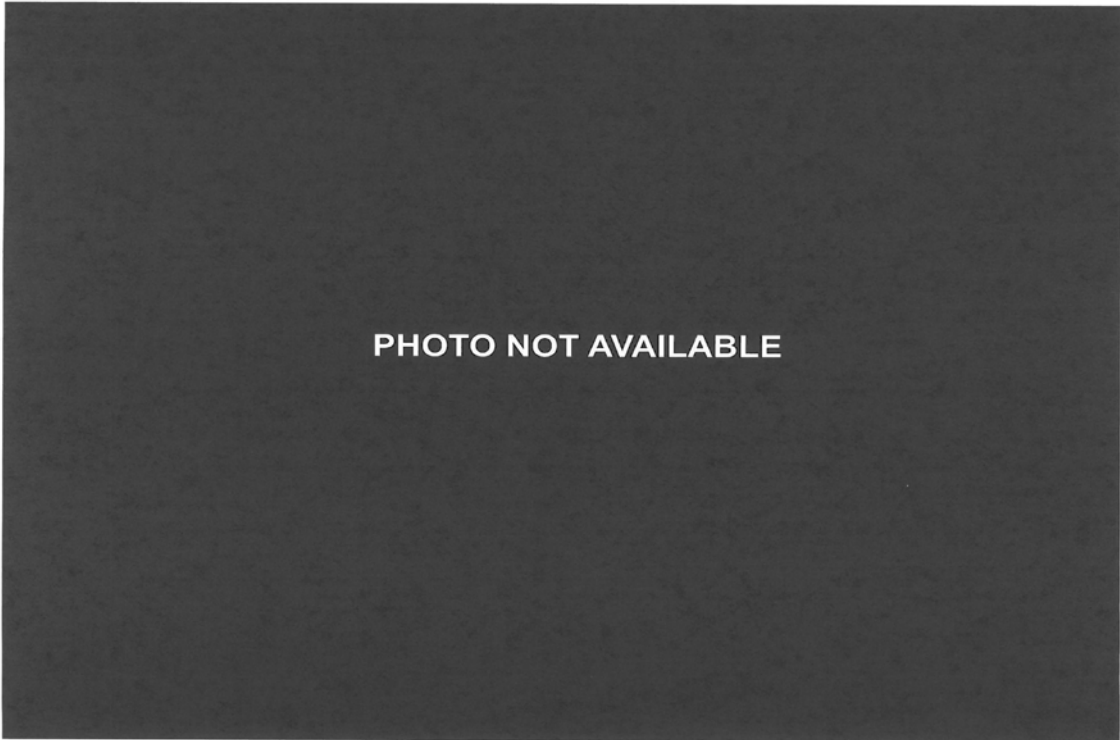
**Figure A-43 Post-Test Bullet Vehicle Rear Underbody View**



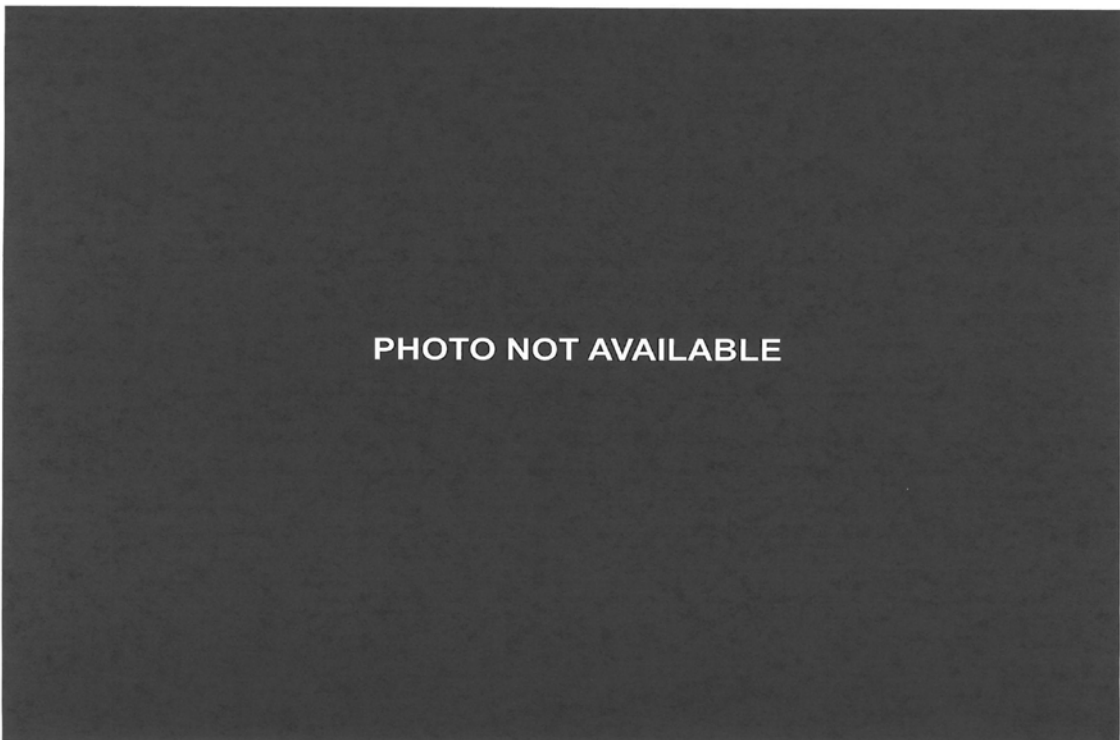
**Figure A-44 Pre-Test Bullet Vehicle Fuel Tank View**



**Figure A-45 Post-Test Bullet Vehicle Fuel Tank View**



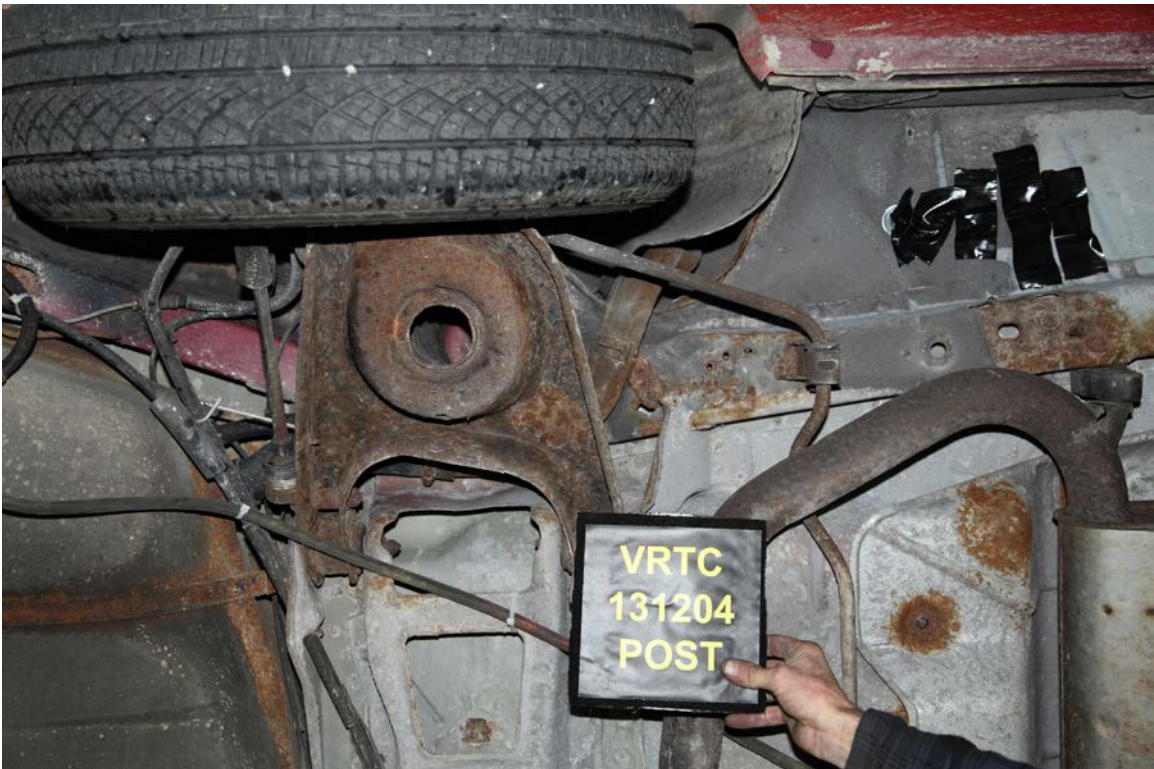
**Figure A-46 Pre-Test Bullet Vehicle Fuel Line Close-up View**



**Figure A-47 Post-Test Bullet Vehicle Fuel Line Close-up View**



**Figure A-48 Pre-Test Bullet Vehicle Fuel Filler Close-up View**



**Figure A-49 Post-Test Bullet Vehicle Fuel Filler Close-up View**

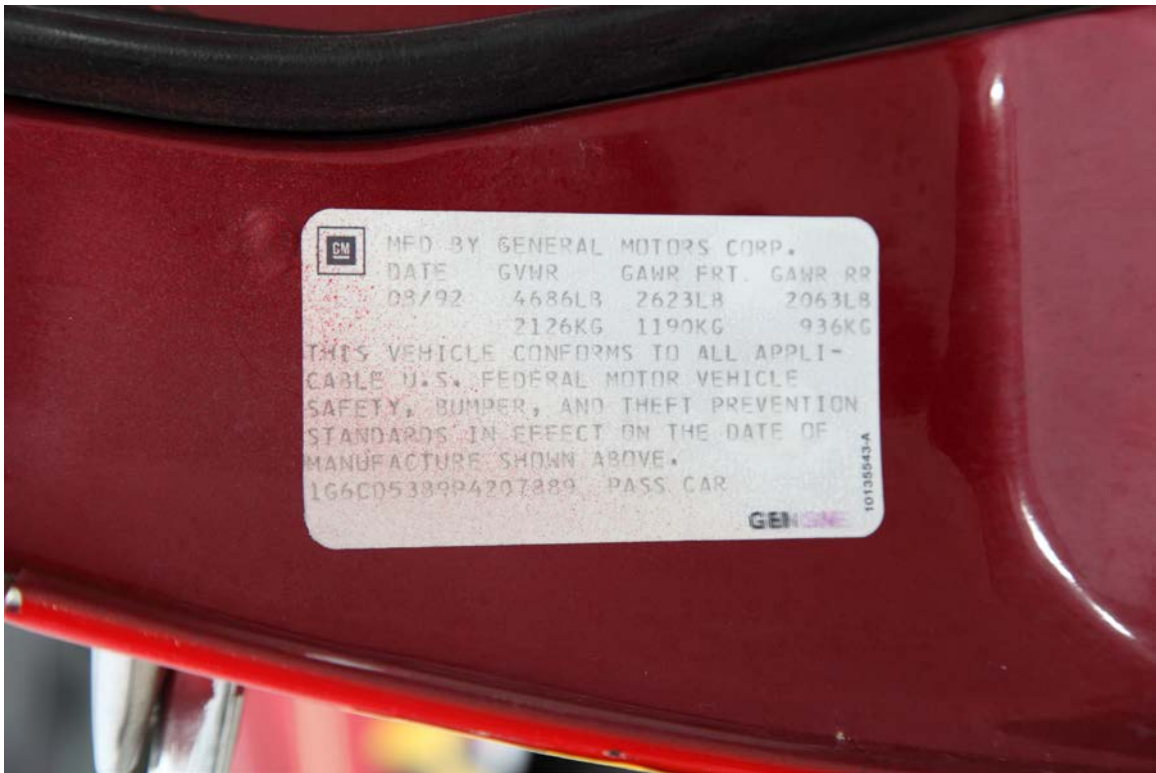


Figure A-50 Close-Up View of Bullet Vehicle Certification Label



Figure A-51 Close-Up View of Bullet Vehicle Tire Information Placard or Label



**Figure A-52 Pre-Test Bullet and Target Vehicles Overall Left Side View**



**Figure A-53 Post-Test Bullet and Target Vehicles Overall Left Side View**



**Figure A-54 Pre-Test Bullet and Target Vehicles Overall Right Side View**



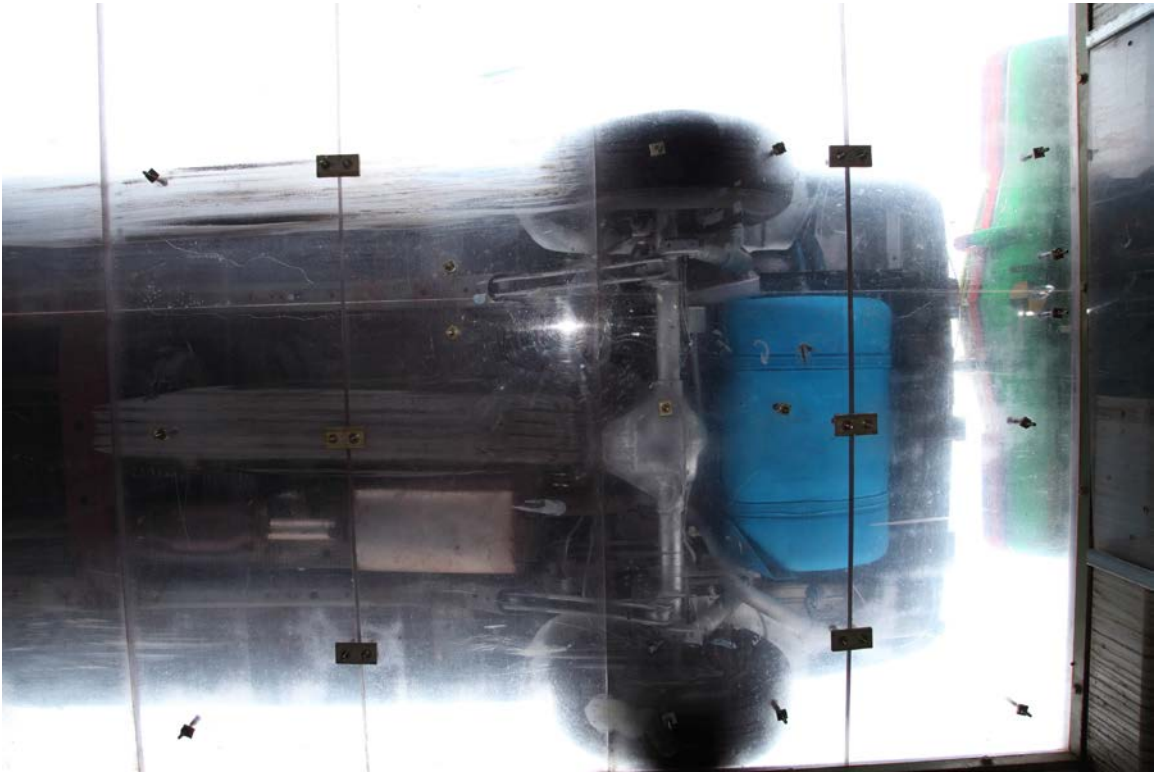
**Figure A-55 Post-Test Bullet and Target Vehicles Overall Right Side View**



Figure A-56 Pre-Test Bullet and Target Vehicles Overhead View



Figure A-57 Post-Test Bullet and Target Vehicles Overhead View



**Figure A-58 Pre-Test Impact Alignment – Bullet and Target Vehicles Pit View**

**Intentionally Left Blank**



**Figure A-59 Target Vehicle at 90° on Static Rollover Device**



**Figure A-60 Target Vehicle at 180° on Static Rollover Device**



Figure A-61 Target Vehicle at 270° on Static Rollover Device

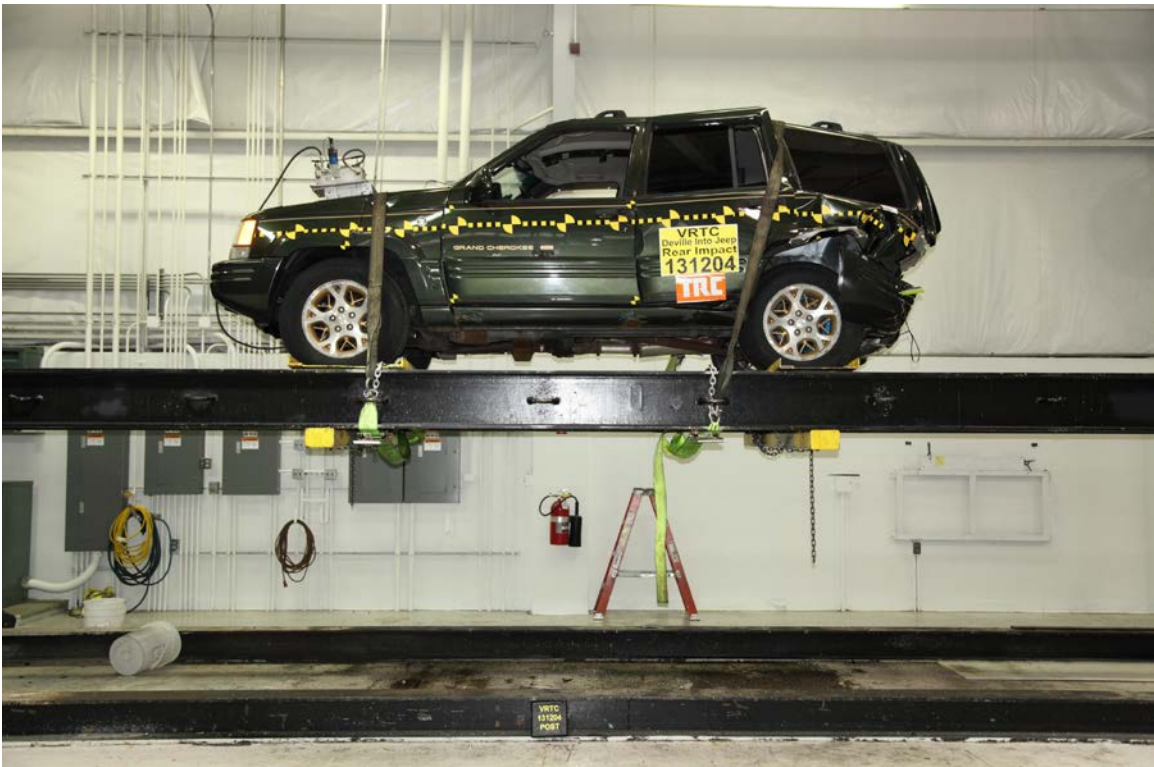


Figure A-62 Target Vehicle at 360° on Static Rollover Device

## Appendix B

### Data Plots



# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

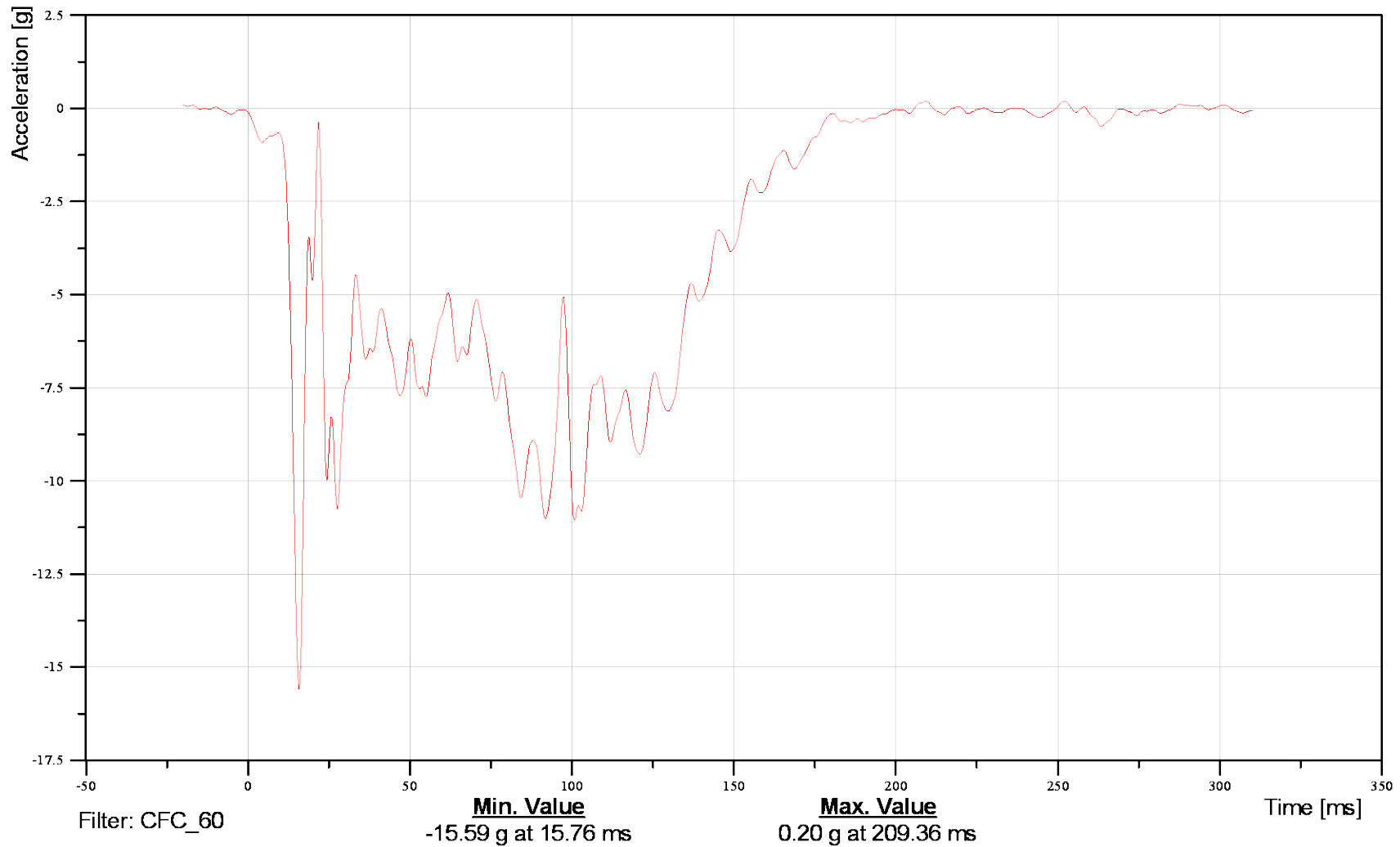
Bullet Bullet Vehicle CG X

Customer: VRTC

## 10VEHCCG0000ACXD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

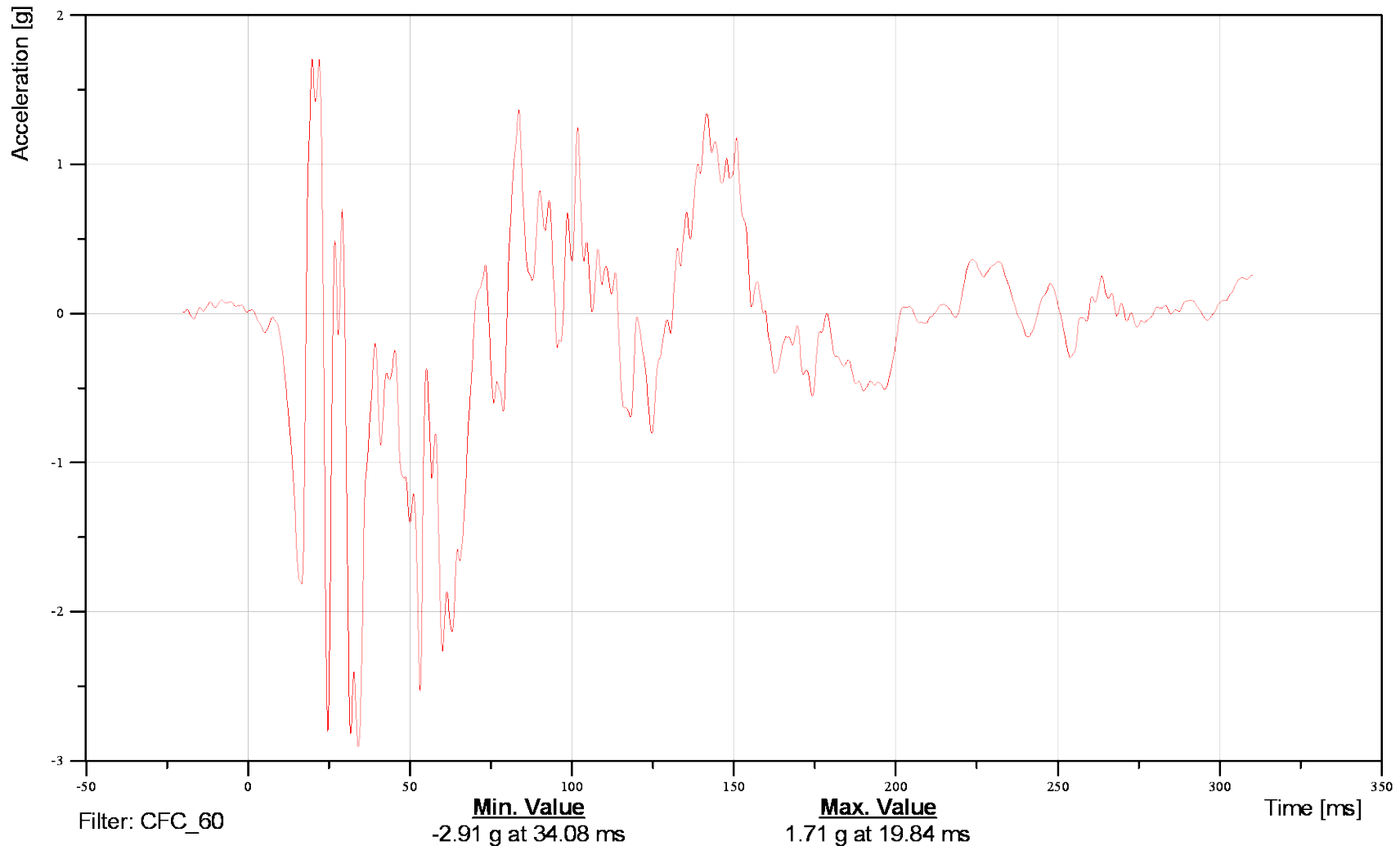
Bullet Bullet Vehicle CG Y

Customer: VRTC

## 10VEHCCG0000ACYD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

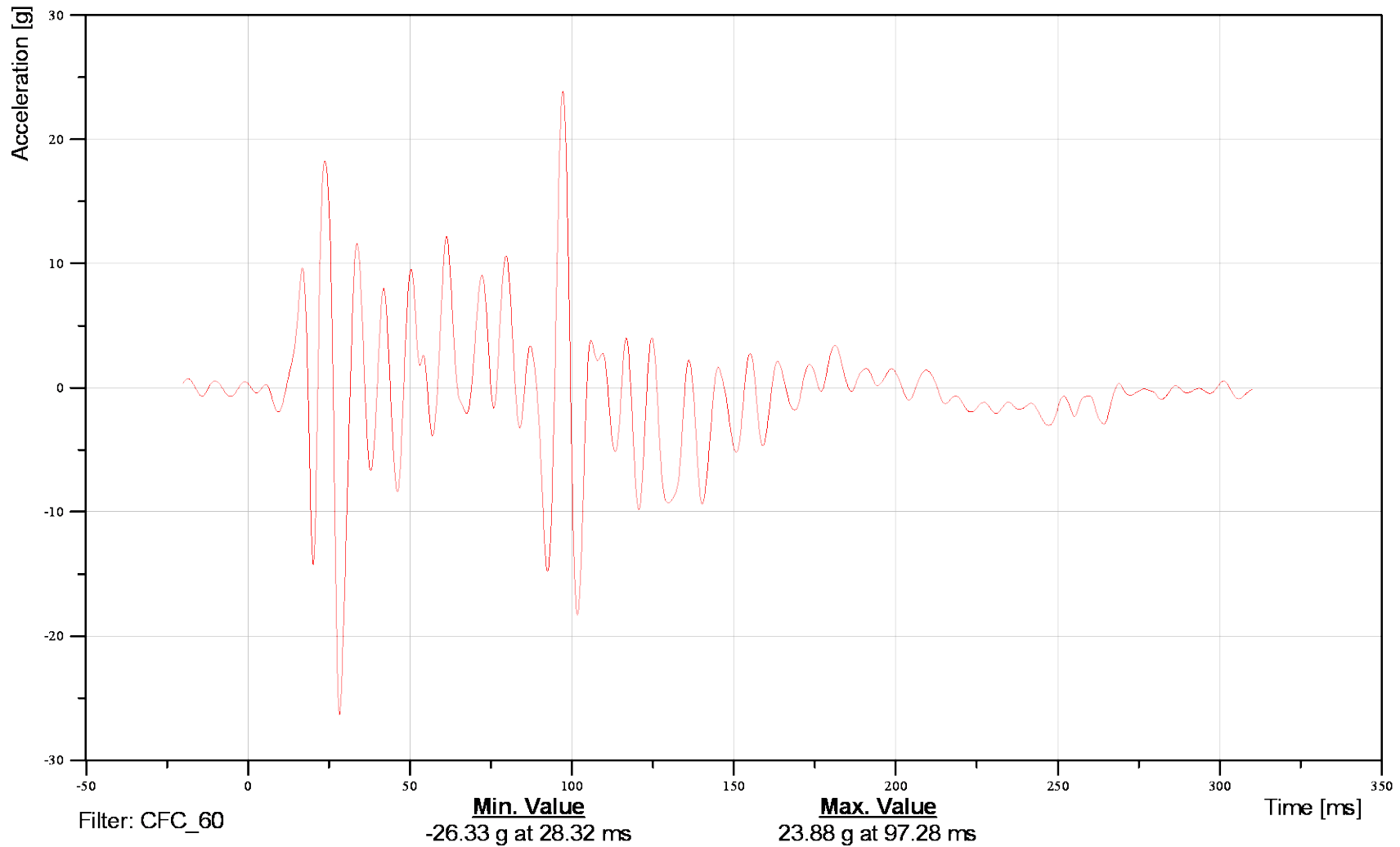
Bullet Bullet Vehicle CG Z

Customer: VRTC

## 10VEHCCG0000ACZD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

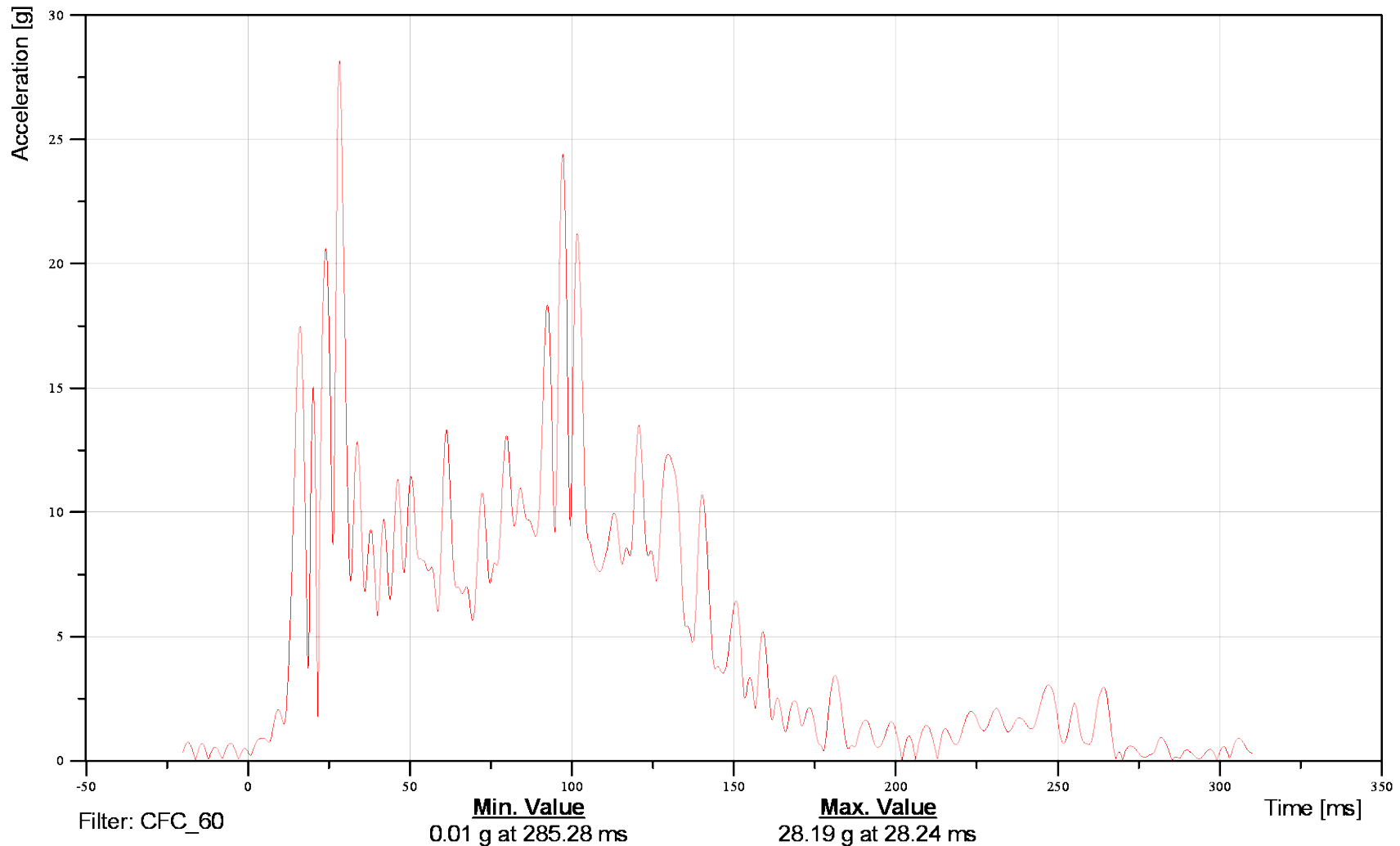
## Bullet Vehicle CG Acceleration Resultant

Customer: VRTC

# 10VEHCCG0000ACRD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

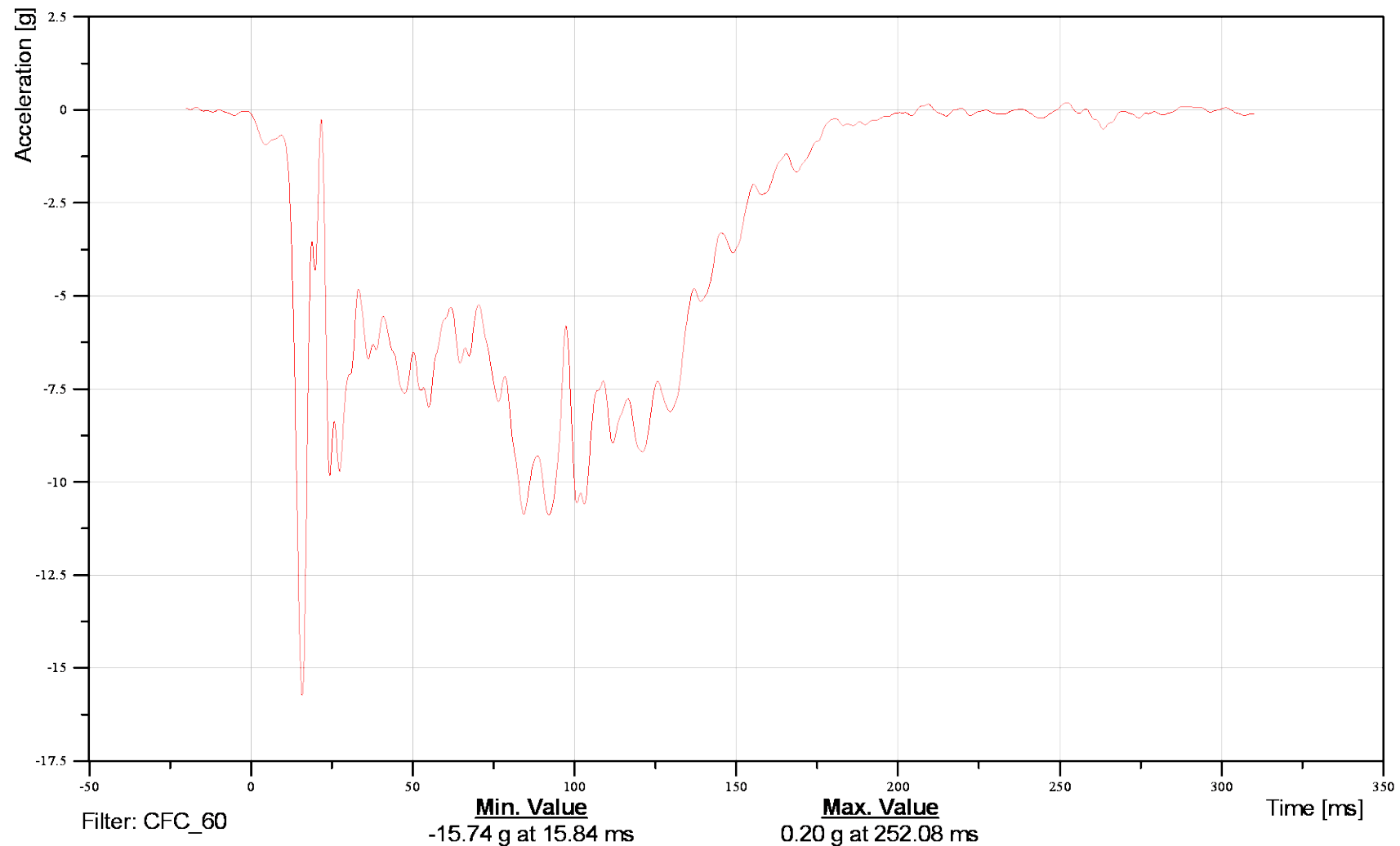
Bullet Vehicle CG Redundant X

Customer: VRTC

## 10VEHCGRD00ACXD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

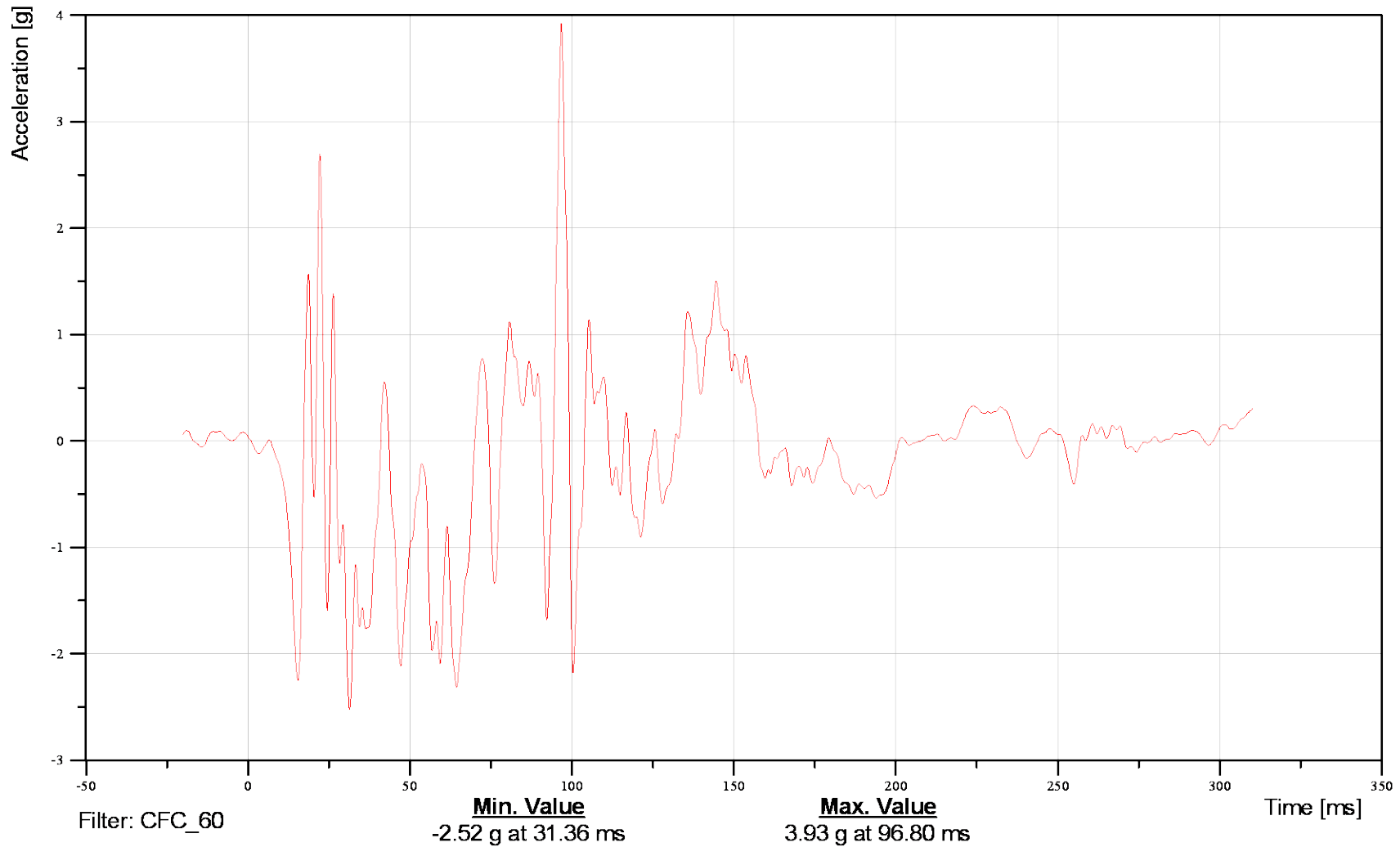
Bullet Vehicle CG Redundant Y

Customer: VRTC

## 10VEHCCGRD00ACYD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

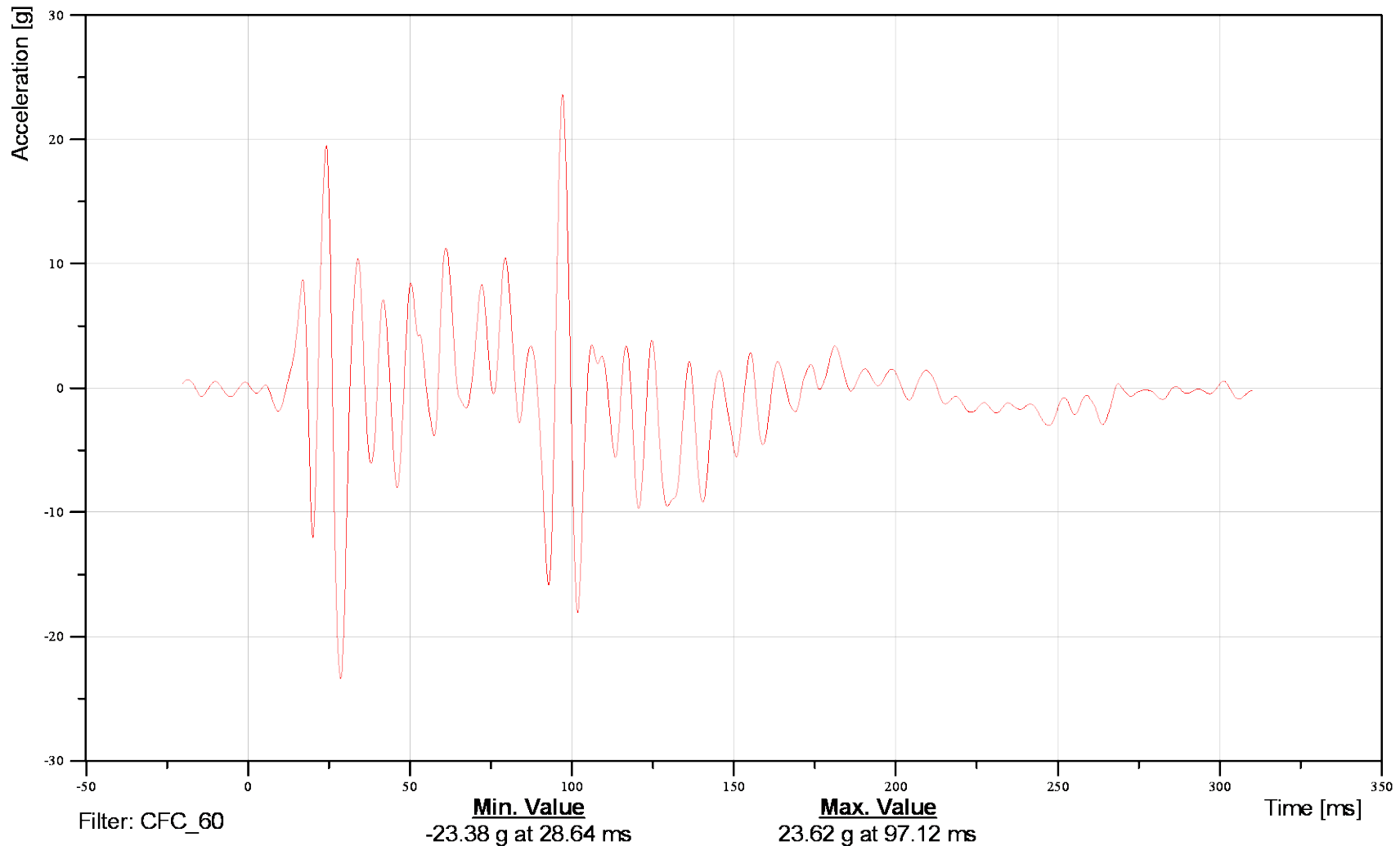
Bullet Vehicle CG Redundant Z

Customer: VRTC

## 10VEHCCGRD00ACZD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

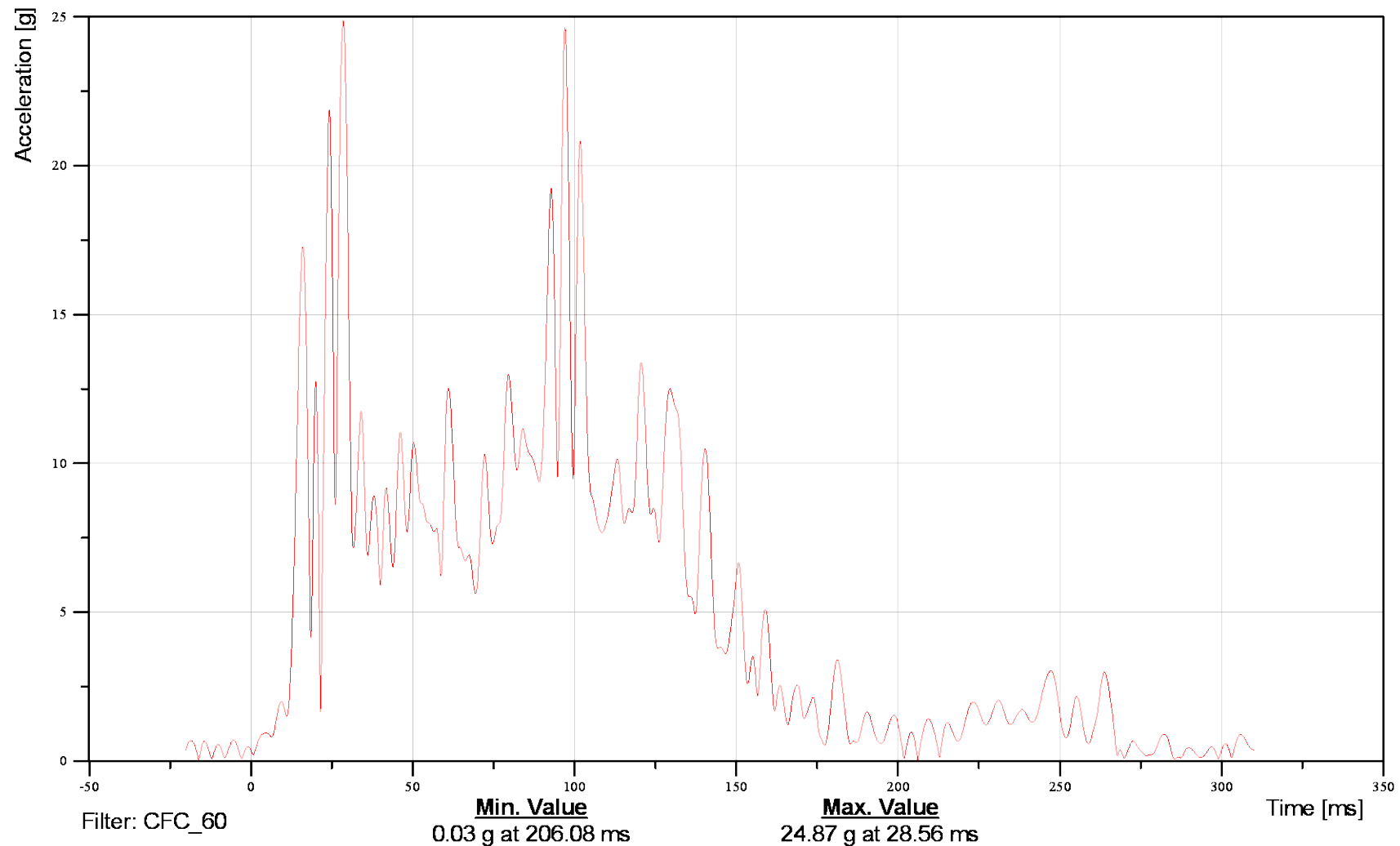
## Bullet Vehicle CG Redundant Acceleration Resultant

Customer: VRTC

# 10VEHCCGRD00ACRD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

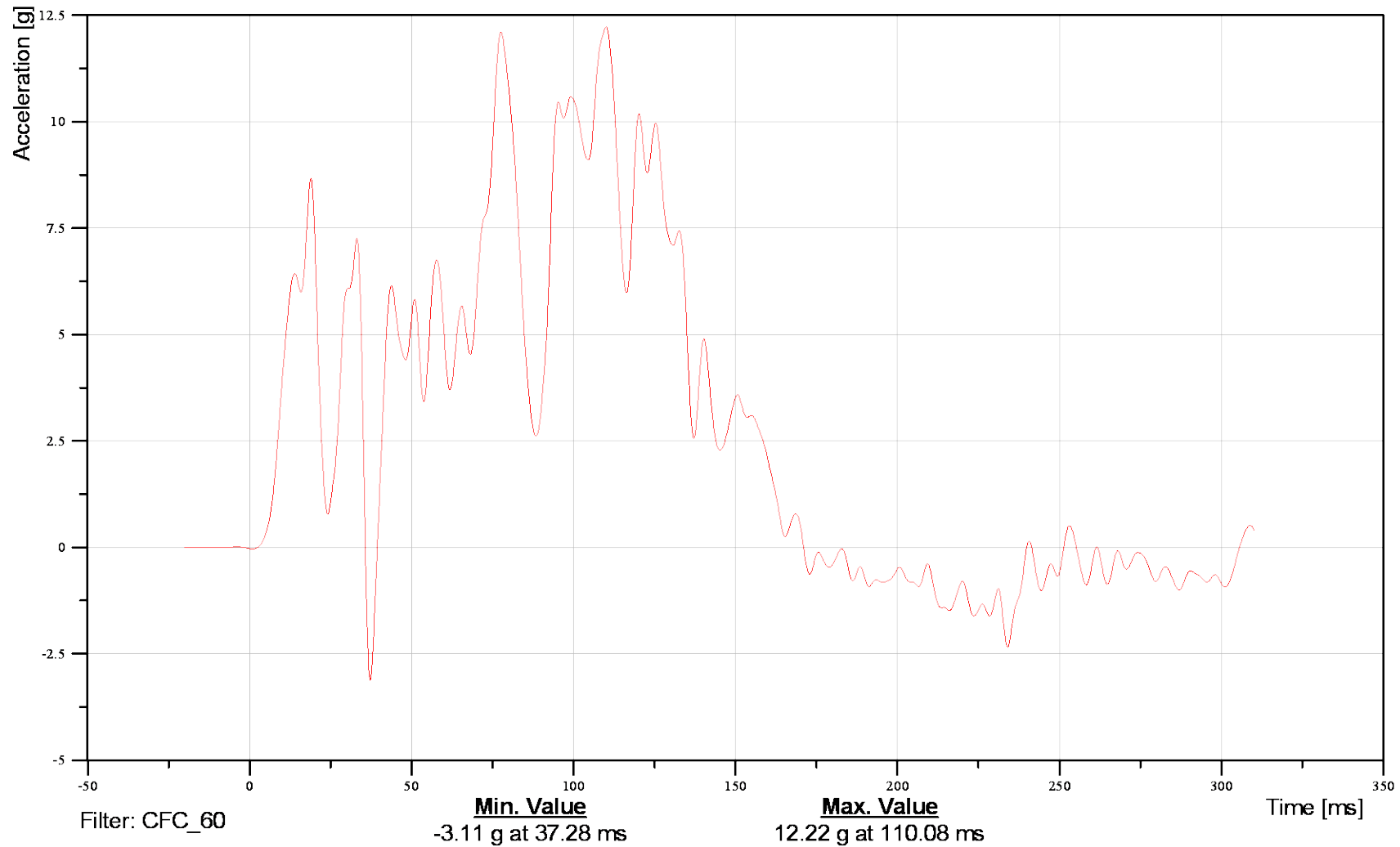
Target Target Vehicle CG X

Customer: VRTC

## 20VEHCCG0000ACXD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

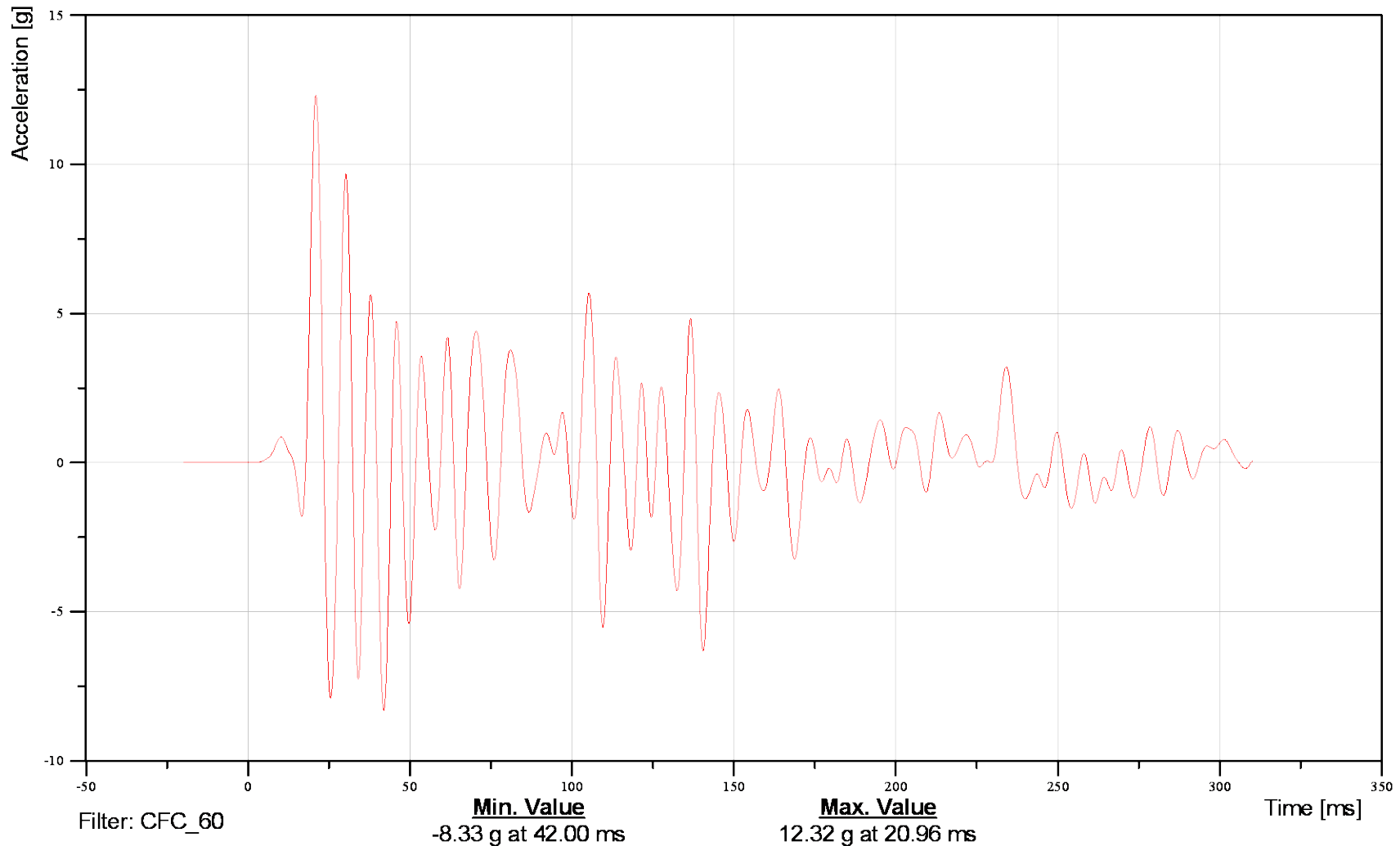
Target Target Vehicle CG Y

Customer: VRTC

## 20VEHCCG0000ACYD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

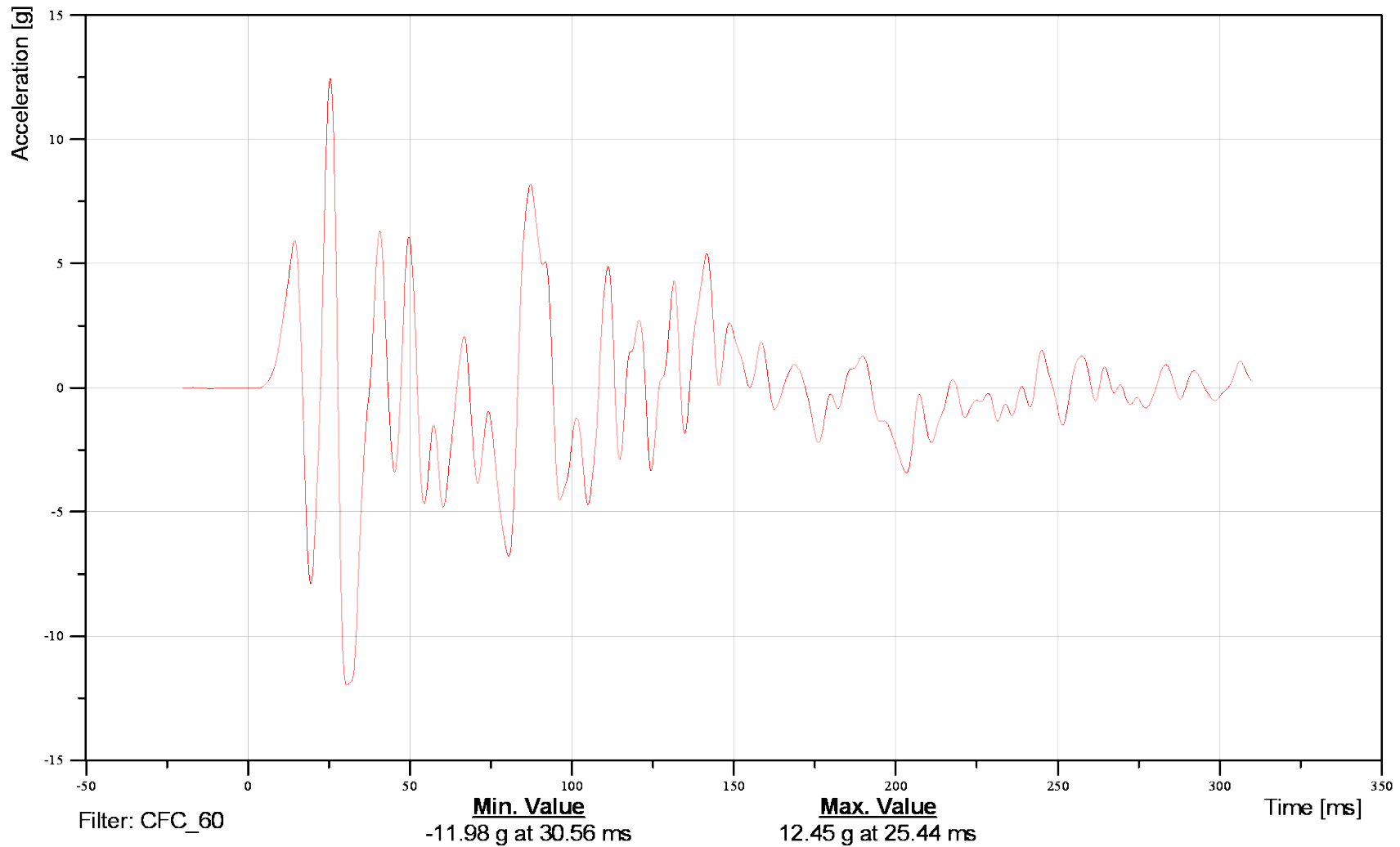
Target Target Vehicle CG Z

Customer: VRTC

## 20VEHCCG0000ACZD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

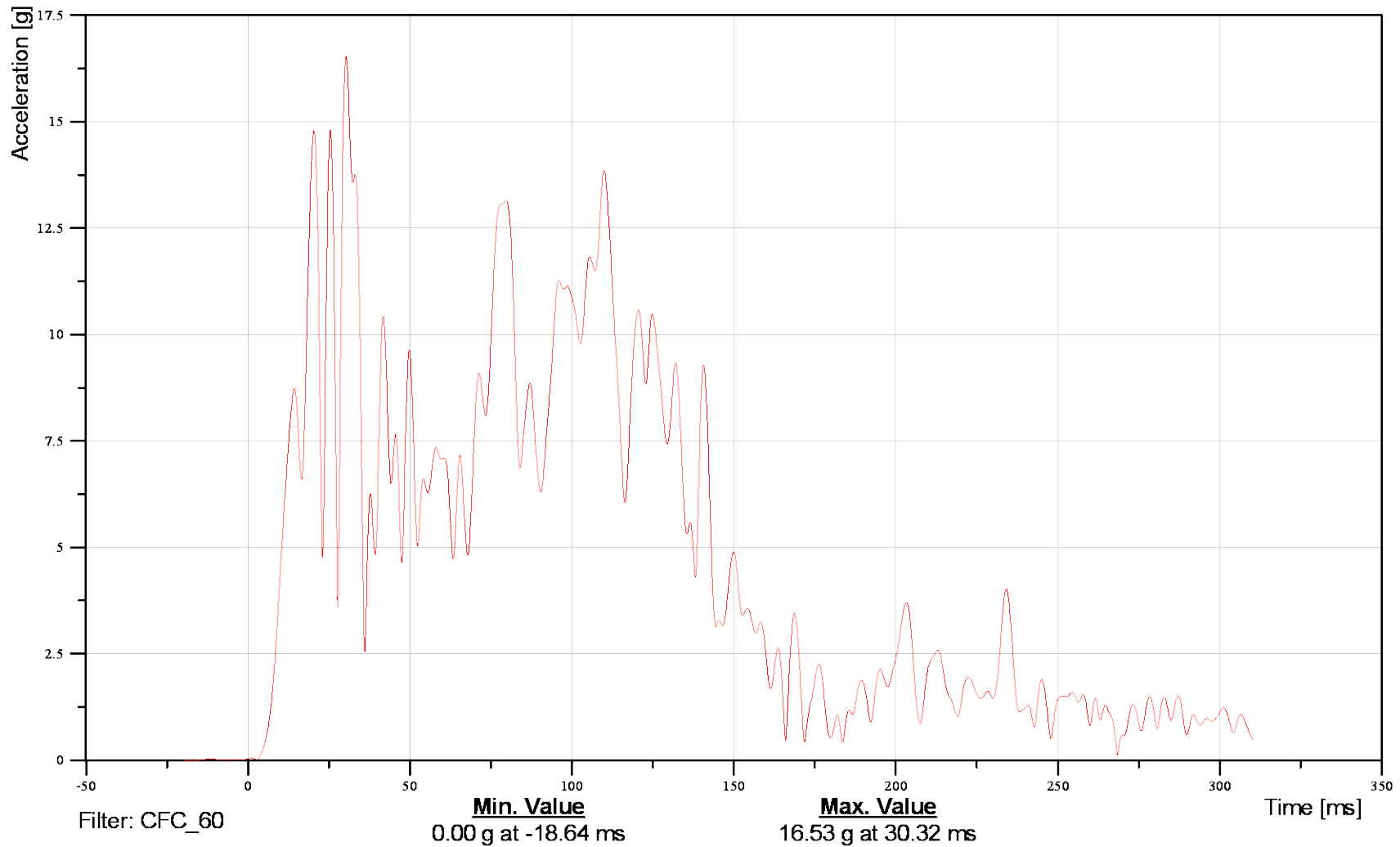
## Target Vehicle CG Acceleration Resultant

Customer: VRTC

# 20VEHCCG0000ACRD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

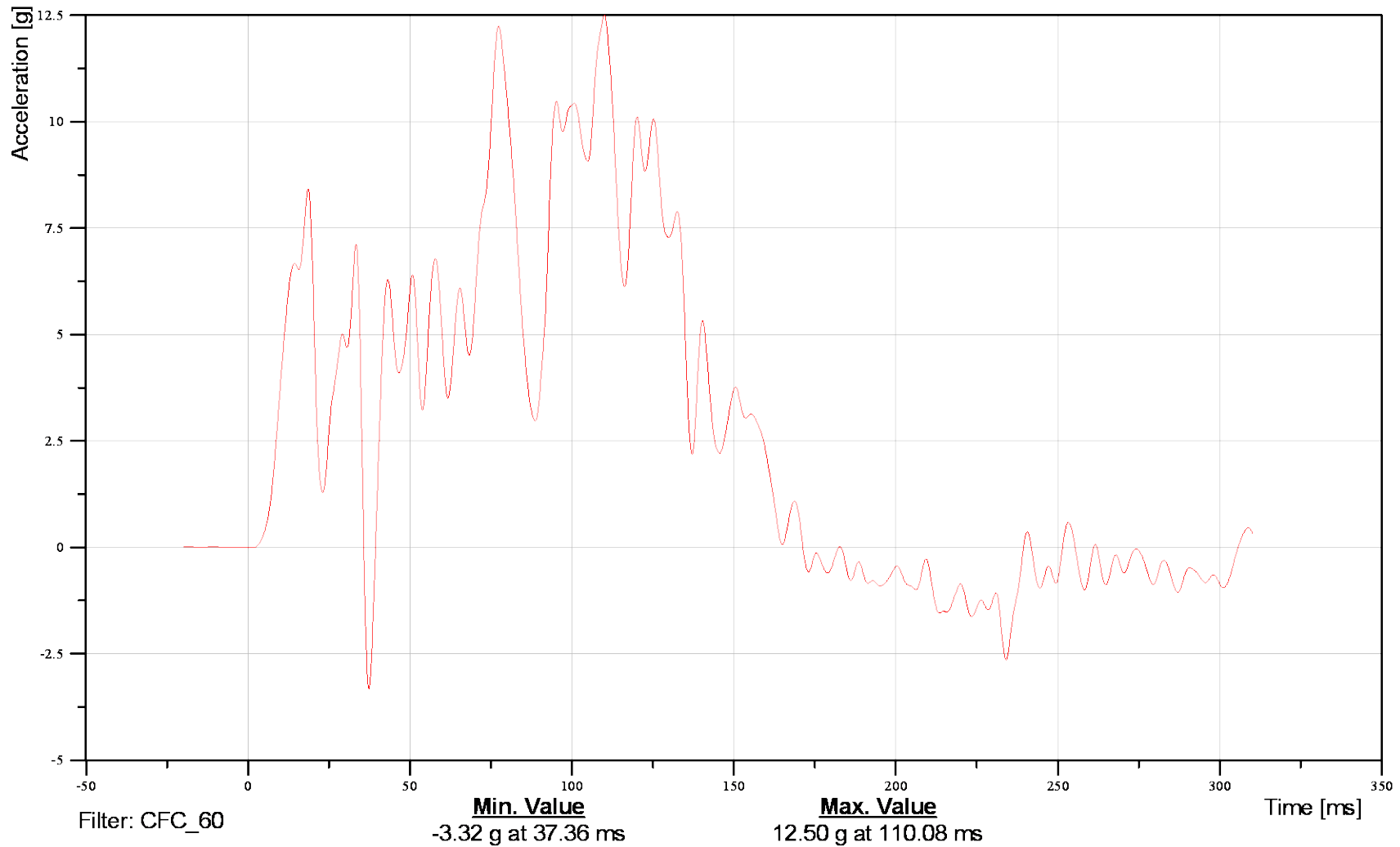
Target Vehicle CG Redundant X

Customer: VRTC

## 20VEHCGRD00ACXD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

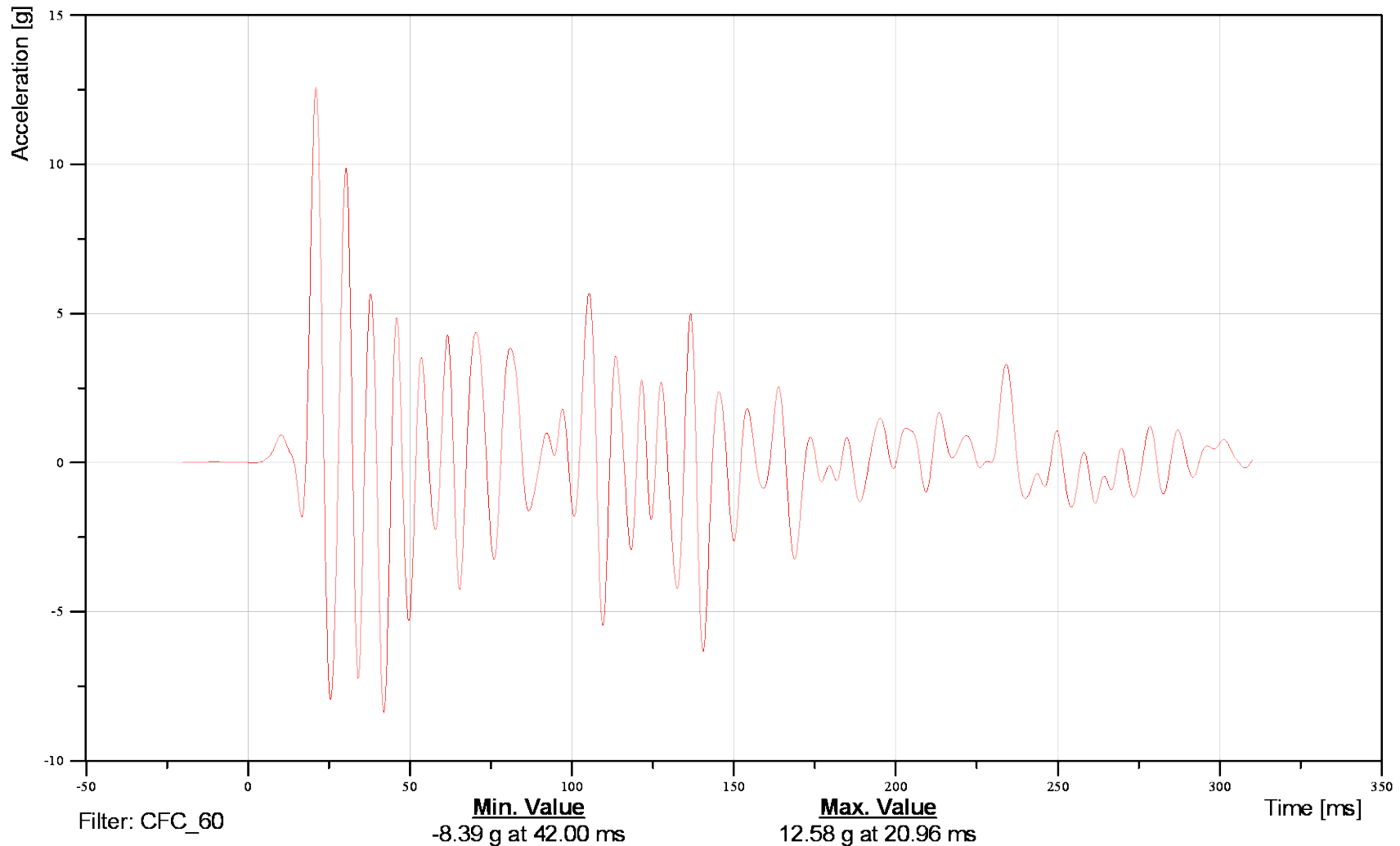
Target Vehicle CG Redundant Y

Customer: VRTC

## 20VEHCGRD00ACYD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013  
Time: 11:42

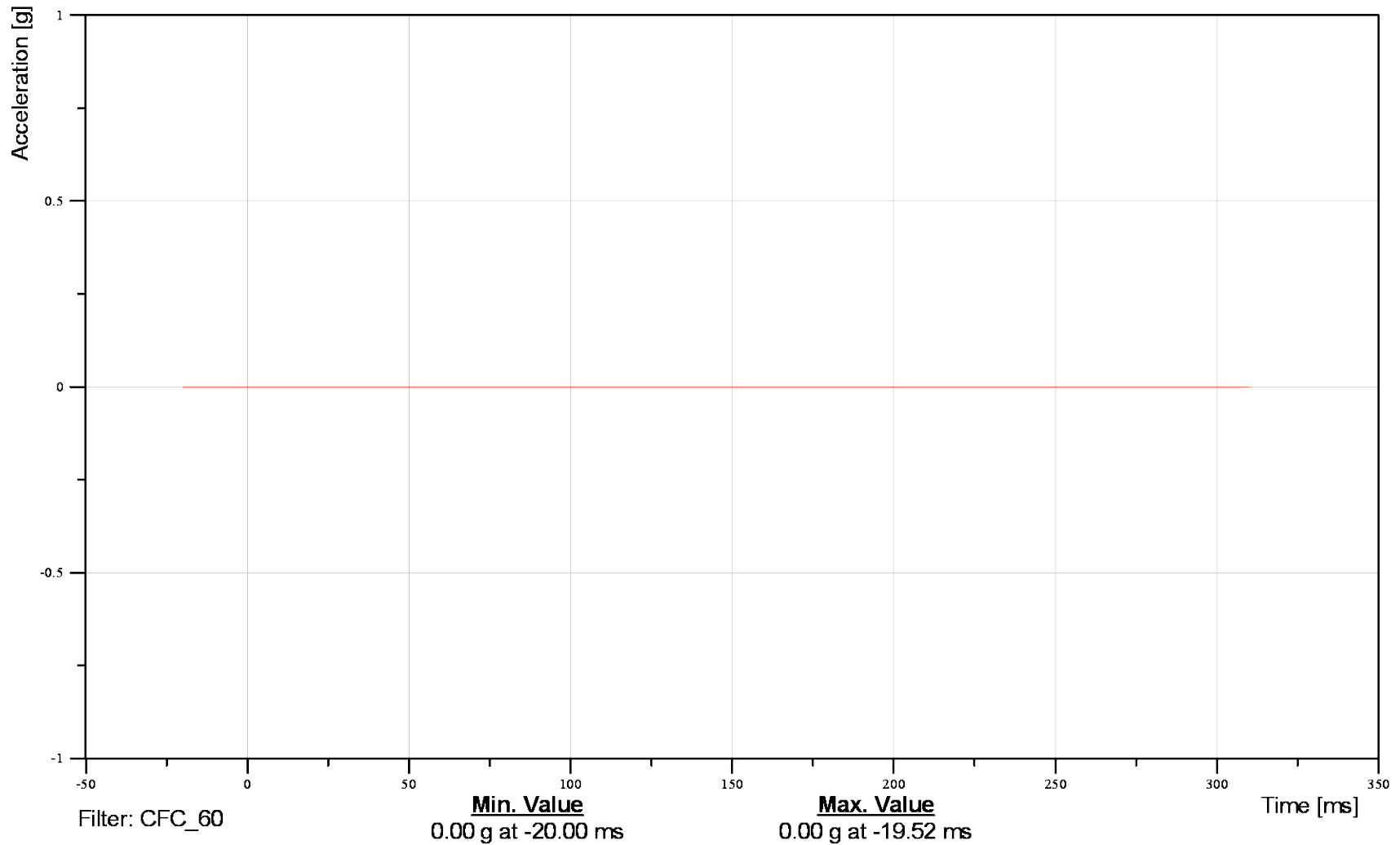
Target Vehicle CG Redundant Z

Customer: VRTC

## 20VEHCCGRD00ACZD

TRC Inc. Test Lab: CTF

Test Number: 131204





# 1993 Cadillac Deville Into Rear of 1996 Jeep GC-ZJ

Date: 12/04/2013

## Target Vehicle CG Redundant Acceleration Resultant

Time: 11:42

Customer: VRTC

# 20VEHCCGRD00ACRD

TRC Inc. Test Lab: CTF

Test Number: 131204

