Force Balance Review

Force Balance is an application of Equal but Opposite Forces. By calculating the Force applied to a vehicle based on the damage and known stiffness values, that Force is then applied to the other vehicle, from which stiffness values for that vehicle can then be calculated. An extension of this also allows for the calculation of delta-v and the Kinetice Energy Equivalent Speed (BEV/BES/EBS/EBV) for each vehicle, and the closing speed between the two vehicles. The typical use of Force Balance is when you have one vehicle where you have more confidence in the "known" stiffness values for that vehicle, and/or a crash situation where one of the vehicles either has no stiffness data available, or a crash situation which is unusual or does not fit the normal crash situation such as an under ride.

In each of these tests conducted this year, the test parameters exceed the "normal" application of speed from crush calculations due to one or more of the following - approach speed, area of the vehicle impacted on the target vehicle, and bumper mis-match.

The crush measurements used for the Force Balance analysis in these tests would be considered to be "crude" by most. No jigs were used, no total station, no scanner, none of the high tech tools. These tools would improve the quality of the measurements, and SHOULD be used whenever possible. However, this was undertaken to illustrate that crush measurements can be taken in the field (or in the impound yard) without taking an extreme amount of time.

The measurements were taken to what can be referred to as "inflection points" in the crush damage. These points can also be referred to as bend points. IF equally spaced measurements are required at a later point in time, they can be measured from a scale drawing of the damage profile.

Part of this write up review is to point out the areas which need to be paid attention to as weaknesses in the data and/or the analysis. The calculated speeds should be compared to the instrumented speeds by the reader. The calculations were completed without knowing the actual instrumented impact speeds.

If there are any questions after reviewing this data, please feel free to email or call me, it WILL NOT be a bother.

Daniel Vomhof III dv3@4n6xprt.com (619) 464-3478

Gillig Bus into Pontiac Grand Am - Side

Crash Test 1 2008 Gillig Transit Bus into the side of a 2003 Pontiac Grand Am

The crash setup mimics a vehicle that began a right turn into a cross street, then came to a stop, but within the curb side travel lane.

This is a good situation in which to apply a Force Balance analysis since there are no sources for stiffness values for the front of the transit bus.

At the same time, a Force Balance analysis in this case suffers since the vehicle with the "known" stiffness values is based on side stiffness, which typically have more uncertainty about them than frontal values. One should keep this in mind when looking at the results.

When conducting a Force Balance analysis, setting the lever arm and angle to the collision face to zero will result in the minimum calculated closing speed. Under this set up, the calculated closing speed based on the average side stiffness values in this test is 29.1 mph, with a plus/minus 1 Standard Deviation range of 26-32 mph.

When the angle to the collision face is changed to 30 degrees on the Pontiac, the calculated closing speed based on the average side stiffness values in this test is 32 mph, with a plus/minus 1 Standard Deviation range of 28.3-35.3 mph.

The two page calculation results for each of these test situations follow.

2002 PONTIAC GRAND AM - Side Impact

		_				
Curb Weight (pour Occupant + Cargo Weight (pour	· -	0		er Arm Distance	`	0.00
Total Weight (pou	nds): 305	0	Yaw Mon	nent of Inertia (lb-ft-sec*)	1935.50
Angle Coll Force to Normal (degr	ees): 0.	0	"Known" Stif	ffness Values		
No Damage Speed (m	anh): 2	0				В
3 ,		_		Average	141.7	207.1
Energy Crush Depth (inc	hes): 6.0	15	N	Minimum	122.5	139.7
Damage Length (inc	hes): 86 .	.0	N	/laximum	180.5	295.9
Crush Profile Measureme	ents:	4	Std.	Devation	26.2	65.2
	Unequal		Zone	Area	Zone	Area
	Spacing	Zone Area	Depth(x)	Depth(x)	Depth(y)	Depth(y)
C1 (inches) 0.00	(inches)	(inches²)	(inches)	(inches³)	(inches)	(inches³)
` '	42.00	252.00	4.00	1008.00	28.00	7056.00
C2 (inches) 12.00	30.00	240.00	4.33	1040.00	42.50	10200.00
C3 (inches) 4.00	14.00	28.00	1.33	37.33	32.67	914.67
C4 (inches) 0.00		20.00		57.55	32.07	514.07
C5 (inches)						
C6 (inches)						
C7 (inches)						
C8 (inches)						
C9 (inches)						
C10 (inches)						
Average Crush (inches):	6.05					

Results			Average		KE		Closing
Results			Force	Damage	Speed	Delta V	Speed
	Α	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	(MPH)
Minimum	122.5	139.7	41610.46	29987.07	17.2	23.4	25.9
Avg - 2 Std. Deviations	89.3	76.7	23793.41	17580.90	13.2	20.2	22.4
Avg - 1 Std. Deviations	115.5	141.9	41881.79	30018.06	17.2	23.4	26.0
Average	141.7	207.1	59970.17	42501.43	20.4	26.3	29.1
Avg + 1 Std. Deviations	167.9	272.3	78058.55	54997.82	23.3	28.8	31.9
Avg + 2 Std. Deviations	194.1	337.5	96146.93	67499.69	25.8	31.1	34.5
Maximum	180.5	295.9	84739.89	59671.23	24.2	29.7	32.9
Damage Centroid Depth (>	() (inches)	4.01			k²	2942.47	7
Damage Centroid Depth (y	/) (inches)	34.94		Eff. Mass Ratio (gamma)	1.00)
Area of Damage	(inches²):	520.30					

4N6XPRT StifCalcs® licensed by 4N6XPRT Systems (www.4N6XPRT.com) to:

Serial Number: 21R-030201SC01301

Registered Owner: 4N6XPRT SYSTEMS

Curb Weight (pounds): 28200 Occupant + Cargo Weight (pounds): 0 Total Weight (pounds): 28200 Angle Coll Force to Normal (degrees): 0.0 No Damage Speed (mph): 5.0 Energy Crush Depth (inches): 1.25	3.00
Total Weight (pounds): 28200 Yaw Moment of Inertia (lb-ft-sec²) 27703 Angle Coll Force to Normal (degrees): 0.0 No Damage Speed (mph): 5.0	3.00
No Damage Speed (mph): 5.0	
No Damage Speed (mph): 5.0	
Energy Crush Depth (inches).	
Damage Length (inches): 44.0	
Damage Length (inches).	
Crush Profile Measurements: 2	
Equal Zone Area Zone Are	
Spacing Zone Area Depth(x) Depth(x) Depth(y) Depth (inches) (inches²) (inches³) (inches) (inches)	
C1 (inches) 2.50	06.67
C2 (inches) 44.00 55.00 0.83 45.83 14.67 80	70.07
C3 (inches)	
C4 (inches)	
C5 (inches)	
C6 (inches)	
C7 (inches)	
C8 (inches)	
C9 (inches)	
C10 (inches)	
Average Crush (inches): 1.25	
Average	
Results Force Damage Speed Delta V	
A B (poundsf) Energy (ft*lbs) (mph) bs	sub1
Minimum 1632.3 207.2 41610.46 31846.15 5.8 2.5	11.2
Avg - 2 Std. Deviations 986.8 75.7 23793.41 28385.37 5.5 2.2	6.8
Avg - 1 Std. Deviations 1641.7 209.6 41881.79 31898.13 5.8 2.5	11.2
Average 2238.7 389.8 59970.17 35322.48 6.1 2.8	15.3
	19.1
Avg + 1 Std. Deviations 2790.9 605.8 78058.55 38678.39 6.4 3.1	
Avg + 1 Std. Deviations 2790.9 605.8 78058.55 38678.39 6.4 3.1 Avg + 2 Std. Deviations 3307.1 850.6 96146.93 41979.29 6.7 3.4	
	22.6
Avg + 2 Std. Deviations 3307.1 850.6 96146.93 41979.29 6.7 3.4	22.6
Avg + 2 Std. Deviations 3307.1 850.6 96146.93 41979.29 6.7 3.4 Maximum 2985.4 693.1 84739.89 39903.48 6.5 3.2	22.6

2002 PONTIAC GRAND AM - Side Impact

6.05

Average Crush (inches):

Registered Owner: 4N6XPRT SYSTEMS

Curb Weight (pour Occupant + Cargo Weight (pour Total Weight (pour	nds):	0		er Arm Distance	`	0.00
Angle Coll Force to Normal (degr No Damage Speed (m Energy Crush Depth (inc Damage Length (inc Crush Profile Measureme	hes): 6.0 hes): 86	0.0 0.0 0.0 0.0	1	Average Maximum Devation	A 141.7 122.5 180.5 26.2	B 207.1 139.7 295.9 65.2
C1 (inches)	Unequal Spacing (inches) 42.00 30.00 14.00	Zone Area (inches²) 252.00 240.00 28.00	Zone Depth(x) (inches) 4.00 4.33 1.33	Area Depth(x) (inches³) 1008.00 1040.00 37.33	Zone Depth(y) (inches) 28.00 42.50 32.67	Area Depth(y) (inches³) 7056.00 10200.00 914.67

Results			Average		KE		Closing
Results			Force	Damage	Speed	Delta V	Speed
	Α	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	(MPH)
Minimum	122.5	139.7	48047.61	39982.76	19.8	25.6	28.3
Avg - 2 Std. Deviations	89.3	76.7	27474.26	23441.20	15.2	21.8	24.1
Avg - 1 Std. Deviations	115.5	141.9	48360.92	40024.07	19.8	25.7	28.3
Average	141.7	207.1	69247.58	56668.57	23.6	29.0	32.0
Avg + 1 Std. Deviations	167.9	272.3	90134.24	73330.43	26.9	32.0	35.3
Avg + 2 Std. Deviations	194.1	337.5	111020.91	89999.59	29.8	34.7	38.3
Maximum	180.5	295.9	97849.19	79561.65	28.0	33.0	36.5
Damage Centroid Depth (x	() (inches)	4.01			k²	2942.4	7
Damage Centroid Depth (y	/) (inches)	34.94		Eff. Mass Ratio (gamma)	1.0	0
Area of Damage	(inches²):	520.30					

4N6XPRT StifCalcs® licensed by 4N6XPRT Systems (www.4N6XPRT.com) to:

Serial Number: 21R-030201SC01301

Curb Weight (po	unds): 282	200	PDOF .		r	1
ccupant + Cargo Weight (po	=======================================	50	L	ever Arm Distanc	e (inches): L	0.00
Total Weight (po		50	Yaw M	oment of Inertia	(lb-ft-sec²)	28784.50
gle Coll Force to Normal (de	grees):	0.0				
No Damage Speed	(mph):	5.0				
Energy Crush Depth (i	nches): 1	.25				
Damage Length (i	nches): 4	4.0				
Crush Profile Measure	ments:	2				
	Equal		Zone	Area	Zone	Area
	Spacing (inches)	Zone Area (inches²)	Depth(x) (inches)	Depth(x) (inches³)	Depth(y) (inches)	Depth(y) (inches ³)
C1 (inches) 2.50	44.00	55.00			14.67	806.67
C2 (inches) 0.00] [] [75.83	14.07	
C3 (inches)]	l]	J		
C4 (inches)]		J			
C5 (inches)	7					
C6 (inches)	- -					
C7 (inches)	; ===					
` ' -	-					
C8 (inches)	; ===					
C9 (inches)						
C10 (inches)						
Average Crush (inches):	1.25					
Results			Average		KE	
11054115	Α	В	Force (poundsf)	Damage Energy (ft*lbs)	Speed Delta (mph) (mph	
Minimum	1859.8	259.3	48047.61	33965.42	5.9	2.7 12.3
	1129.3	95.6	27474.26	29991.97	5.5	
Avg - 2 Std. Deviations						2.3 7.5
Avg - 1 Std. Deviations	1870.4	262.3	48360.92	34025.05	5.9	2.7 12.3
Average	2542.0	484.5	69247.58	37952.09	6.2	3.0 16.8
Avg + 1 Std. Deviations	3160.7	749.1	90134.24	41798.26	6.5	3.3 20.9
Avg + 2 Std. Deviations	3737.3	1047.3	111020.91	45580.11	6.8	3.6 24.7
Maximum	3378.1	855.7	97849.19	43201.96	6.7	3.4 22.3
Damage Centroid Depth (x) (inches)	0.83			k ² 45	63.01
Damage Centroid Depth (y) (inches)	14.67	E	ff. Mass Ratio (ga	amma)	1.00
Area of Damage	(inches²)·	55.00				

Nissan Sentra into Gillig Bus Rear

Crash Test 2 2014 Nissan Sentra into the Rear of a 2008 Gillig Transit Bus

In this test there is no lever arm or angle to the collision face issues to consider.

The front bumper of the Nissan Sentra did underride the bus rear bumper. Also significant speed was involved as evidenced by the Nissan's engine which was pushed into the passenger compartment.

The calculated closing speed based on the average front stiffness values for the Sentra in this test is 73.9 mph, with a plus/minus 1 Standard Deviation range of 55.9-88.3 mph.

The two page calculation result for this test situation follows.

2014 NISSAN SENTRA - Front Impact

Curb Weight (poun	· —	=	PDOF	Lever Arm Dista	ance (inches):	0.00
Occupant + Cargo Weight (poun Total Weight (pour		<u>0</u> 7	Yaw N	Noment of Iner	tia (lb-ft-sec²)	1716.11
ngle Coll Force to Normal (degre	ees): 0	.0	"Known"	Stiffness Valu	es A	В
No Damage Speed (m	ph): 0 .	.0		Average [402.7	176.1
Energy Crush Depth (inch	nes): 25.0	0		Minimum [331.5	114.9
Damage Length (inch	nes): 69	.0		Maximum	473.8	237.3
Crush Profile Measureme	ents:	2	S	td. Devation [100.6	86.6
	Equal		Zone	Area	Zone	Area
	Spacing	Zone Area	Depth(x)		Depth(y)	Depth(y)
C1 (inches) 25.00	(inches)	(inches²)	(inches)	(inches³)	(inches)	(inches³)
	69.00	1725.00	12.5	0 21562.5	0 34.50	59512.50
C2 (inches) 25.00		Г	Г	–	¬	
C3 (inches)						
C4 (inches)						
C5 (inches)						
C6 (inches)					_	
C7 (inches)					_	
C8 (inches)						
C9 (inches)						
C10 (inches)						
Average Crush (inches):	25.00					

Results			Average		KE	Closing	
Results			Force	Damage	Speed	Delta V Speed	
	Α	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph) (MPH)	
Minimum	331.5	114.9	110538.00	256863.76	52.1	56.1 61.7	
Avg - 2 Std. Deviations	201.5	2.9	9453.00	74428.79	28.1	31.4 34.5	
Avg - 1 Std. Deviations	302.1	89.5	87616.20	207178.87	46.8	50.8 55.9	
Average	402.7	176.1	165779.40	376965.35	63.1	67.1 73.9	
Avg + 1 Std. Deviations	503.3	262.7	243942.60	547160.68	76.1	80.2 88.3	
Avg + 2 Std. Deviations	603.9	349.3	322105.80	717460.78	87.1	91.4 100.6	
Maximum	473.8	237.3	221017.35	497226.95	72.5	76.6 84.3	
Damage Centroid Depth (x	() (inches)	12.50			k²	2804.81	
Damage Centroid Depth (y	y) (inches)	34.50		Eff. Mass Ratio (gamma)	1.00	
Area of Damage	(inches²):	1725.00					

4N6XPRT StifCalcs® licensed by 4N6XPRT Systems (www.4N6XPRT.com) to:

2008 GILLIG LOW F	LOOR TR	ANSIT B	US - Rear I	mpact		
Curb Weight (po	unds): 282		PDOF Le	ver Arm Distan	ce (inches):	0.00
Occupant + Cargo Weight (po	· -	0		oment of Inertia	` ′ -	27703.00
Total Weight (po	unas): <u>262</u>	<u>00</u>			· · · ·	
ngle Coll Force to Normal (deg		0.0				
No Damage Speed (5.0				
Energy Crush Depth (in		.00				
Damage Length (in	ches): 50	0.0				
Crush Profile Measuren	nents:	2				
	Unequal		Zone	Area	Zone	Area
	Spacing	Zone Area	,	Depth(x)	Depth(y)	Depth(y)
C1 (inches) 6.00		(inches²)	(inches)	(inches³)	(inches)	(inches³)
C2 (inches) 0.00	50.00	150.00	2.00	300.00	16.67	2500.00
C3 (inches)	i] [
C4 (inches)	1					
C5 (inches)	ʻi					
C6 (inches)	ʻi 🗀					
C7 (inches)	ʻi 🗀					
C8 (inches)	ʻi 🗀					
C9 (inches)	ʻi 🗀					
C10 (inches)	ʻi 🗀					
Average Crush (inches):	3.00					
			Average		KE	
Results			Force	Damage	Speed Delt	a V
	Α	В	(poundsf) E	Energy (ft*lbs)	(mph) (mp	oh) bsub1
Minimum	2612.3	603.1	110538.00	71303.50	8.7	5.6 20.3
Avg - 2 Std. Deviations	346.3	10.6	9453.00	28167.06	5.5	3.2 2.7
Avg - 1 Std. Deviations	2209.9	431.6	87616.20	61986.24	8.1	5.1 17.2
Average	3459.0	1057.4	165779.40	93245.27	10.0	6.8 26.9
Avg + 1 Std. Deviations	4467.1	1763.5	243942.60	123500.02	11.5	8.1 34.7
Avg + 2 Std. Deviations	5335.8	2516.2	322105.80	153174.04	12.8	9.2 41.5
M	/1000	1550.6	221017 25	11/609 65	110	77 226

4N6XPRT StifCalcs® licensed by 4N6XPRT Systems (www.4N6XPRT.com) to:

16.67

150.00

4555.08

1.00

Eff. Mass Ratio (gamma)

Registered Owner: 4N6XPRT SYSTEMS Serial Number: 21R-030201SC01301 Registered Owner: 4N6XPRT SYSTEMS Serial Number: 21R-030201SC01301

Damage Centroid Depth (x) (inches)

Damage Centroid Depth (y) (inches)

Area of Damage (inches²):

Chevrolet Malibu into Gillig Bus Rear Axle

Crash Test 3 2004 Chevrolet Malibu into the side of a 2008 Gillig Transit Bus

In this test impact was into the side of the bus near the rear axle. Much of the contact area involved the rear tire of the bus.

Again, the minimum calculated closing speed is achieved by setting the angle to the collision face and the lever arm to zero.

Under this set up, the calculated closing speed based on the average front stiffness values for the Malibu in this test is 59.8 mph, with a plus/minus 1 Standard Deviation range of 51.2-67.3 mph.

When the lever arm is changed to 94 inches, the distance the rear axle is behind the bus CG based on its weight distribution, the calculated closing speed based on the average front stiffness values for the Malibu in this test is 65.5 mph, with a plus/minus 1 Standard Deviation range of 56.1-73.7 mph.

The two page calculation results for each of these test situations follow.

2004 CHEVROLET MALIBU - Front Impact

	A B d (mph): 5.0 Average 375.1 131.5
Spacing Zone Area Depth(x) Depth(x) Depth(y) Continues Continues	(inches): 43.0 Maximum 496.8 232.8
C7 (inches) C8 (inches) C9 (inches) C10 (inches)	Spacing Zone Area Depth(x) Depth(x) Depth(y) Depth(y) (inches) (inches²) (inches) (inches³) (inches³) 23.00 736.00 16.26 11963.83 12.34 9081.17 20.00 710.00 17.81 12643.33 29.67 21066.67

Results			Average		KE		Closing
Results			Force	Damage	Speed	Delta V	Speed
	Α	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	(MPH)
Minimum	291.3	86.7	68950.95	214655.23	44.4	44.1	49.3
Avg - 2 Std. Deviations	270.5	55.1	45655.53	147971.47	36.9	36.7	40.9
Avg - 1 Std. Deviations	322.8	93.3	74400.30	232233.43	46.2	45.9	51.2
Average	375.1	131.5	103145.07	316789.70	54.0	53.6	59.8
Avg + 1 Std. Deviations	427.4	169.7	131889.84	401441.52	60.8	60.3	67.3
Avg + 2 Std. Deviations	479.7	207.9	160634.61	486136.23	66.9	66.3	74.0
Maximum	496.8	232.8	179006.08	539176.36	70.4	69.9	78.0
Damage Centroid Depth (x	() (inches)	17.02			k²	3061.62	2
Damage Centroid Depth (y	v) (inches)	20.85		Eff. Mass Ratio (gamma)	1.00	D
Area of Damage	(inches²):	1446.09					

4N6XPRT StifCalcs® licensed by 4N6XPRT Systems (www.4N6XPRT.com) to:

2008 GILLIG LOW F	LOOK IKAN	211 RO2	- Side Ir	npact		
Curb Weight (pou	nds): 28200	Ī	PDOF Lev	er Arm Distand	re (inches).	0.00
Occupant + Cargo Weight (pou	·			ment of Inertia	_	27703.00
Total Weight (pou	ınds): 28200	L	Taw IVIO	nent of Inertia	(10-11-360)	27703.00
ngle Coll Force to Normal (deg	rees): 0.0					
No Damage Speed (r	mph): 1.0					
Energy Crush Depth (inc	ches): 2.50					
Damage Length (inc	ches): 59.0					
Crush Profile Measurem	ents: 3					
	Unequal		Zone	Area	Zone	Area
	-1 3	ne Area	Depth(x)	Depth(x)	Depth(y)	Depth(y)
C1 (inches) 0.00	(inches) (ir	nches²) 97.50	(inches) 1.67	(inches³)	(inches)	(inches³) 2535.00
C2 (inches) 5.00						
C3 (inches) 0.00	20.00	50.00	1.67	83.33	26.67	1333.33
C4 (inches)						
C5 (inches)			-			
C6 (inches)						
C7 (inches)						
C8 (inches)						L
C9 (inches)						F
C10 (inches)						
Average Crush (inches):	2.50					
Results		Av	verage		KE	
Nesults	A B	-	orce oundsf) Er	Damage nergy (ft*lbs)	Speed Delta (mph) (mpl	
Г			68950.95	22255.26		5.1 24.2
Minimum L						
Avg - 2 Std. Deviations			45655.53	15331.81		4.2 19.1
Avg - 1 Std. Deviations			74400.30	23863.34		5.3 25.2
Average L			03145.07	32297.33		6.2 30.3
Avg + 1 Std. Deviations	755.0 148	86.3 1	31889.84	40672.58	6.6	7.0 34.6

4N6XPRT StifCalcs® licensed by 4N6XPRT Systems (www.4N6XPRT.com) to:

160634.61

179006.08

49007.45

54318.30

Eff. Mass Ratio (gamma)

7.2

7.6

38.6

40.9

7.7

8.1

1.00

4555.08

Registered Owner: 4N6XPRT SYSTEMS Serial Number: 21R-030201SC01301 Registered Owner: 4N6XPRT SYSTEMS Serial Number: 21R-030201SC01301

Avg + 2 Std. Deviations

Maximum

Damage Centroid Depth (x) (inches)

Damage Centroid Depth (y) (inches)

Area of Damage (inches²):

840.5

891.2

1841.9

2070.7

1.67

26.23

147.50

2004 CHEVROLET MALIBU - Front Impact

	A B d (mph): 5.0 Average 375.1 131.5
Spacing Zone Area Depth(x) Depth(x) Depth(y) Continues Continues	(inches): 43.0 Maximum 496.8 232.8
C7 (inches) C8 (inches) C9 (inches) C10 (inches)	Spacing Zone Area Depth(x) Depth(x) Depth(y) Depth(y) (inches) (inches²) (inches) (inches³) (inches³) 23.00 736.00 16.26 11963.83 12.34 9081.17 20.00 710.00 17.81 12643.33 29.67 21066.67

Results		Average		KE		Closing			
Results		Force	Damage	Speed	Delta V	Speed			
A	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	(MPH)			
Minimum 29	91.3 86.7	68950.95	214655.23	44.4	40.3	54.0			
Avg - 2 Std. Deviations 27	70.5 55.1	45655.53	147971.47	36.9	33.4	44.8			
Avg - 1 Std. Deviations 32	22.8 93.3	74400.30	232233.43	46.2	41.9	56.1			
Average 37	75.1 131.5	103145.07	316789.70	54.0	48.9	65.5			
Avg + 1 Std. Deviations 42	27.4 169.7	131889.84	401441.52	60.8	55.0	73.7			
Avg + 2 Std. Deviations 47	79.7 207.9	160634.61	486136.23	66.9	60.5	81.1			
Maximum 49	232.8	179006.08	539176.36	70.4	63.8	85.4			
Damage Centroid Depth (x) (inches) 17.02 k ² 3061.62									
Damage Centroid Depth (y) (inches) 20.85 Eff. Mass Ratio (gamma) 1.00									
Area of Damage (inches²): 1446.09									

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Registered Owner: 4N6XPRT SYSTEMS

2008 GILLIG LOW F	LOOR TRANSI	T BUS - Side	Impact		
Curb Weight (pou Occupant + Cargo Weight (pou Total Weight (pou	unds):		ever Arm Distan		94.00 27703.00
Angle Coll Force to Normal (deg No Damage Speed (i Energy Crush Depth (in Damage Length (in Crush Profile Measurem C1 (inches) C2 (inches) C3 (inches) C4 (inches) C5 (inches) C6 (inches) C7 (inches) C8 (inches) C9 (inches) C9 (inches) Average Crush (inches):	mph): 1.0 ches): 2.50 ches): 59.0 ments: 3 Unequal Spacing Zone (inches) (inches) (inches)	Zone Area Depth(x) (inches) 97.50 1.6		Zone Depth(y) (inches) 26.00 26.67	Area Depth(y) (inches²) 2535.00 1333.33
Results	A B	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed Delta (mph) (mp	
Minimum [527.0 724.		22255.26		4.7 24.2
Avg - 2 Std. Deviations	416.6 452. 550.0 788.		15331.81 23863.34		3.9 19.1 4.8 25.2
Avg - 1 Std. Deviations	659.7 1134.		32297.33		5.7 30.3
Average					
Avg + 1 Std. Deviations	755.0 1486.	.3 131889.84	40672.58	6.6	6.4 34.6

Avg + 2 Std. Deviations 840.5 1841.9 160634.61 49007.45 7.0 38.6 Maximum 891.2 2070.7 179006.08 54318.30 7.6 7.4 40.9 Damage Centroid Depth (x) (inches) 1.67 4555.08 Damage Centroid Depth (y) (inches) 26.23 Eff. Mass Ratio (gamma) 0.34 147.50 Area of Damage (inches²):

Pontiac Montana Extended into Ford F600 Rear

Crash Test 4 2001 Pontiac Montana into the Rear of a pre-1980 Ford F600 Dump Truck

In this test there is no lever arm or angle to the collision face issues to consider.

The Ford has no rear bumper, as such the front of the Pontiac Montana did underride the rear of the dump truck. The tow hitch on the Ford offered little resistance to the impact and was broken off in the impact. Primary contact between the two vehicles at the bumper level was between the Pontiac bumper and the protective "shield" for the rear axle and differential of the Ford. There was also significant contact between the bottom of the dump bed and the Pontiacs hood.

The calculated closing speed based on the average front stiffness values for the Montana in this test is 59.5 mph, with a plus/minus 1 Standard Deviation range of 49.6-68 mph.

The two page calculation result for this test situation follows.

2001 PONTIAC MONTANA EXTENDED - Front Impact

Curb Weight (pounds): 3942 Occupant + Cargo Weight (pounds): 0 Total Weight (pounds): 3942	Lever Arm Dista Yaw Moment of Inert	`
ngle Coll Force to Normal (degrees):	"Known" Stiffness Value	A B
No Damage Speed (mph): 5.0	Average [351.4 104.5
Energy Crush Depth (inches): 29.00	Minimum [303.0 79.1
Damage Length (inches): 72.0	Maximum [470.0 183.8
Crush Profile Measurements: 2	Std. Devation	56.9 35.9
Unequal	Zone Area	Zone Area
Spacing Zone Area	Depth(x) Depth(x)	Depth(y) Depth(y)
C1 (inches) (inches) (inches²)	(inches) (inches³)	(inches) (inches ³)
C2 (inches) 29.00 72.00 2088.00	14.50 30276.00	36.00 75168.00
C3 (inches)		
C4 (inches)		
C5 (inches)		
C6 (inches)		
C7 (inches)		
C8 (inches)		
C9 (inches)		
C10 (inches)		
Average Crush (inches): 29.00		

Results			Average		KE		Closing		
Results			Force	Damage	Speed	Delta V	Speed		
	Α	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	(MPH)		
Minimum	303.0	79.1	93488.40	255773.31	44.1	38.3	52.6		
Avg - 2 Std. Deviations	237.6	32.7	42692.40	129023.74	31.3	27.2	37.3		
Avg - 1 Std. Deviations	294.5	68.6	82220.40	228113.67	41.7	36.2	49.6		
Average	351.4	104.5	121748.40	328342.04	50.0	43.4	59.5		
Avg + 1 Std. Deviations	408.3	140.4	161276.40	428835.56	57.1	49.6	68.0		
Avg + 2 Std. Deviations	465.2	176.3	200804.40	529432.25	63.5	55.1	75.6		
Maximum	470.0	183.8	208807.20	549112.95	64.6	56.2	77.0		
Damage Centroid Depth (x) (inches) 14.50 k² 3196.19									
Damage Centroid Depth (y) (inches) 36.00 Eff. Mass Ratio (gamma) 1.00									
Area of Damage (inches²): 2088.00									

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Serial Number: 21R-030201SC01301

Registered Owner: 4N6XPRT SYSTEMS

1978 FORD F600 - Rear Impact	
Curb Weight (pounds): 10635 Occupant + Cargo Weight (pounds): 0	PDOF Lever Arm Distance (inches): 0.00
Total Weight (pounds): 10635	Yaw Moment of Inertia (lb-ft-sec²) 9611.05
ngle Coll Force to Normal (degrees): 0.0	
No Damage Speed (mph): 1.0	
Energy Crush Depth (inches): 1.00	
Damage Length (inches): 96.0	
Crush Profile Measurements: 2	
Unequal	Zone Area Zone Area
Spacing Zone Area	41. () 41. ()
C1 (inches) (inches ²)	
96.00 96.00 96.00 96.00 96.00	0.50 48.00 48.00 4608.00
C3 (inches)	
· · · <u> </u>	
C4 (inches)	
C5 (inches)	
C6 (inches)	
C7 (inches)	
C8 (inches)	
C9 (inches)	
C10 (inches)	
Average Crush (inches): 1.00	
Results	Average KE
	Force Damage Speed Delta V
A B	(poundsf) Energy (ft*lbs) (mph) (mph) bsub1
Minimum 374.0 1573.6	93488.40 9642.42 5.2 14.2 74.0
Avg - 2 Std. Deviations 240.2 649.2	42692.40 4874.25 3.7 10.1 47.6
Avg - 1 Std. Deviations 348.3 1364.6	82220.40 8600.52 4.9 13.4 69.0

	Α	В	(poundst)	Energy (ft*lbs)	(mph)	(mph)	bsub1	
Minimum	374.0	1573.6	93488.40	9642.42	5.2	14.2	74.0	
Avg - 2 Std. Deviations	240.2	649.2	42692.40	4874.25	3.7	10.1	47.6	
Avg - 1 Std. Deviations	348.3	1364.6	82220.40	8600.52	4.9	13.4	69.0	
Average	432.5	2103.9	121748.40	12231.23	5.9	16.1	85.6	
Avg + 1 Std. Deviations	503.9	2856.0	161276.40	15810.85	6.7	18.4	99.8	
Avg + 2 Std. Deviations	567.0	3616.4	200804.40	19357.34	7.4	20.4	112.3	
Maximum	579.0	3771.1	208807.20	20072.25	7.5	20.8	114.6	
Damage Centroid Depth (x) (inches) 0.50 k ² 4190.36								
Damage Centroid Depth (y) (inches) 48.00 Eff. Mass Ratio (gamma) 1.00								
Area of Damage (inches²): 96.00								

Chevrolet Malibu into Ford F600 Rear Axle

Crash Test 5 2004 Chevrolet Malibu into the side of a pre-1980 Ford F600 Dump Truck

In this test impact was into the side of the Ford at the rear axle. Contact was between the front of the Malibu and the Rear tire and axle of the F600.

No permanent damage to the F600 was observed, yet the Force Balance model REQUIRES there be damage to both vehicles. Under these situations I follow the following procedure:

- 1 Set the damage profile to a 2 point measurement with a damage length equal to the diameter fo the tire an a 1 inch crush depth on each end.
- 2 Enter the measured crush file fo the other vehicle as you normally would.

The 1 inch crush depth is used because it is "unitary", as well as being small, but not too small.

Again, the minimum calculated closing speed is achieved by setting the angle to the collision face and the lever arm to zero.

Under this set up, the calculated closing speed based on the average front stiffness values for the Malibu in this test is 46.3 mph, with a plus/minus 1 Standard Deviation range of 41.4-50.8 mph.

When the lever arm is changed to 74 inches, the distance the rear axle is behind the bus CG based on its weight distribution, the calculated closing speed based on the average front stiffness values for the Malibu in this test is 52.9 mph, with a plus/minus 1 Standard Deviation range of 41.4-50.8 mph.

The two page calculation results for each of these test situations follow.

2004 CHEVROLET MALIBU - Front Impact

20.62

Average Crush (inches):

Curb Weight (pou Occupant + Cargo Weight (pou Total Weight (pou	ınds): 0		er Arm Distance ment of Inertia	`	0.00 2153.86
Angle Coll Force to Normal (degr No Damage Speed (n Energy Crush Depth (inc Damage Length (inc Crush Profile Measurem	hes): 5.0 thes): 20.62 thes): 43.0	N	Average Maximum Devation	A 376.9 291.3 496.8 52.4	B 132.7 86.7 232.8 38.0
C1 (inches)	Unequal Spacing Zone Area (inches) (inches²) 25.00 562.50 18.00 324.00	Zone Depth(x) (inches) 11.25 9.23	Area Depth(x) (inches³) 6329.17 2991.00	Zone Depth(y) (inches) 12.59 26.17	Area Depth(y) (inches³) 7083.33 8478.00
C6 (inches)					

Results			Average		KE		Closing	
Results			Force	Damage	Speed	Delta V	Speed	
	Α	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	(MPH)	
Minimum	291.3	86.7	44699.66	90611.55	28.9	30.6	40.0	
Avg - 2 Std. Deviations	272.1	56.7	30986.96	66478.72	24.7	27.4	35.8	
Avg - 1 Std. Deviations	324.5	94.7	48960.10	99516.30	30.3	31.7	41.4	
Average	376.9	132.7	66933.24	132826.95	35.0	35.4	46.3	
Avg + 1 Std. Deviations	429.3	170.7	84906.38	166228.30	39.1	38.9	50.8	
Avg + 2 Std. Deviations	481.7	208.7	102879.52	199670.81	42.9	42.0	54.9	
Maximum	496.8	232.8	113888.42	219411.83	44.9	43.7	57.1	
Damage Centroid Depth (x) (inches) 10.51 k ² 3061.62								
Damage Centroid Depth (y	Damage Centroid Depth (y) (inches) 17.55 Eff. Mass Ratio (gamma) 1.00							
Area of Damage (inches²): 886.50								

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Registered Owner: 4N6XPRT SYSTEMS Serial Number: 15R-030201SC02301

1978 FORD F600 - Side Impact

		$\overline{}$
Curb Weight (pounds): 10635 Occupant + Cargo Weight (pounds): 0 Total Weight (pounds): 10635	PDOF Lever Arm Distance (inches): 0.00 Yaw Moment of Inertia (lb-ft-sec²) 9611.05	۲1
No Damage Speed (mph): 10.0 Energy Crush Depth (inches): 1.00 Damage Length (inches): 45.0 Crush Profile Measurements: 2		
Equal Spacing (inches) (inches²) C1 (inches) 1.00 45.00 45.00 C2 (inches) 1.00	Zone Depth(x) (inches) Area Depth(x) (inches³) Zone Depth(y) Depth(y) (inches³) Area Depth(y) (inches³) 0.50 22.50 22.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 1012.50 101	_

Danulta	-		Average		KE	•		
Results			Force	Damage	Speed	Delta V		
	Α	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	bsub1	
Minimum	1813.3	173.4	44699.66	42685.09	11.0	9.4	16.8	
Avg - 2 Std. Deviations	1289.5	87.7	30986.96	40560.30	10.7	8.4	12.0	
Avg - 1 Std. Deviations	1971.1	204.9	48960.10	43336.10	11.1	9.7	18.3	
Average	2614.4	360.4	66933.24	46040.00	11.4	10.9	24.3	
Avg + 1 Std. Deviations	3225.2	548.5	84906.38	48682.92	11.7	11.9	29.9	
Avg + 2 Std. Deviations	3807.9	764.5	102879.52	51273.27	12.0	12.9	35.3	
Maximum	4152.5	909.2	113888.42	52836.87	12.2	13.4	38.5	
Damage Centroid Depth (x) (inches) 0.50 k ² 4190.36								
Damage Centroid Depth (y) (inches) 22.50 Eff. Mass Ratio (gamma) 1.00								
Area of Damage (inches²): 45.00								

2004 CHEVROLET MALIBU - Front Impact

20.62

Average Crush (inches):

Registered Owner: 4N6XPRT SYSTEMS

Curb Weight (poo Occupant + Cargo Weight (poo Total Weight (poo	unds):		er Arm Distance ment of Inertia (` ' =	0.00 2153.86
Angle Coll Force to Normal (deg No Damage Speed (Energy Crush Depth (in Damage Length (in Crush Profile Measuren	mph): 5.0 ches): 20.62 ches): 43.0	N	Average Maximum Devation	A 376.9 291.3 496.8 52.4	B 132.7 86.7 232.8 38.0
	Unequal Spacing Zone Area (inches) (inches²)	Zone Depth(x) (inches)	Area Depth(x) (inches³)	Zone Depth(y) (inches)	Area Depth(y) (inches³)
C1 (inches) 22.00 C2 (inches) 23.00	25.00 562.50 18.00 324.00	11.25 9.23	6329.17	12.59	7083.33
C3 (inches) 13.00 C4 (inches)					
C5 (inches)					
C7 (inches)					
C9 (inches)					

Results			Average		KE		Closing
Results			Force	Damage	Speed	Delta V	Speed
	Α	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	(MPH)
Minimum	291.3	86.7	44699.66	90611.55	28.9	26.8	45.7
Avg - 2 Std. Deviations	272.1	56.7	30986.96	66478.72	24.7	24.0	41.0
Avg - 1 Std. Deviations	324.5	94.7	48960.10	99516.30	30.3	27.7	47.3
Average	376.9	132.7	66933.24	132826.95	35.0	31.0	52.9
Avg + 1 Std. Deviations	429.3	170.7	84906.38	166228.30	39.1	34.0	58.0
Avg + 2 Std. Deviations	481.7	208.7	102879.52	199670.81	42.9	36.7	62.7
Maximum	496.8	232.8	113888.42	219411.83	44.9	38.3	65.3
Damage Centroid Depth (x	i) (inches)	10.51			k²	3061.62	2
Damage Centroid Depth (y) (inches)	17.55		Eff. Mass Ratio (gamma)	1.00	0
Area of Damage	(inches²):	886.50					

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Serial Number: 15R-030201SC02301

1978 FORD F600 - Side Impact

Curb Weight (pounds):	10635
Occupant + Cargo Weight (pounds):	0
Total Weight (pounds):	10635

PDOF	Lever Arm Distance (inches):	74.00
Yav	Moment of Inertia (lb-ft-sec²)	9611.05

Angle Coll Force to Normal (degrees): 0.0 No Damage Speed (mph): [10.0

Energy Crush Depth (inches): 1.00 Damage Length (inches): 45.0

Crush Profile Measureme	ents:	2				
	Equal		Zone	Area	Zone	Area
	Spacing	Zone Area	Depth(x)	Depth(x)	Depth(y)	Depth(y)
C1 (inches) 1.00	(inches)	(inches²)	(inches)	(inches³)	(inches)	(inches³)
CI (menes)	45.00	45.00	0.50	22.50	22.50	1012.50
C2 (inches) 1.00						
C3 (inches)						
C4 (inches)						
C5 (inches)						
C6 (inches)						
C7 (inches)						
C8 (inches)						
C9 (inches)						
C10 (inches)						

Average Crush (inches): 1.00

Results			Average		KE		
Results			Force	Damage	Speed	Delta V	
	Α	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	bsub1
Minimum [1813.3	173.4	44699.66	42685.09	11.0	8.2	16.8
Avg - 2 Std. Deviations	1289.5	87.7	30986.96	40560.30	10.7	7.4	12.0
Avg - 1 Std. Deviations	1971.1	204.9	48960.10	43336.10	11.1	8.5	18.3
Average [2614.4	360.4	66933.24	46040.00	11.4	9.5	24.3
Avg + 1 Std. Deviations	3225.2	548.5	84906.38	48682.92	11.7	10.4	29.9
Avg + 2 Std. Deviations	3807.9	764.5	102879.52	51273.27	12.0	11.3	35.3
Maximum [4152.5	909.2	113888.42	52836.87	12.2	11.7	38.5
Damage Centroid Depth (x)	(inches)	0.50			k²	4190.36	6
Damage Centroid Depth (y)	(inches)	22.50		Eff. Mass Ratio (gamma)	0.43	3
Area of Damage (inches²):	45.00					

The following pages repeat the Force Balance results at full size for easier reading.

Also included is the test data that establishes the stiffness values for each of the "known" vehicles in these crash tests.

Gillig Bus into Pontiac Grand Am - Side

2002 PONTIAC GRAND AM - Side Impact

2002 I OITITAC GIV	AIID AIVI	Side IIII	pact			
Curb Weight (pou			PDOF Lev	ver Arm Distanc	e (inches):	0.00
Occupant + Cargo Weight (pour Total Weight (pour To		<u>0</u> 50	Yaw Moi	ment of Inertia	(lb-ft-sec²)	1935.50
3 .				: CC		
Angle Coll Force to Normal (deg	,	0.0	"Known" St	iffness Values	Α	В
No Damage Speed (-	2.0		Average	141.7	207.1
Energy Crush Depth (in	, <u> </u>	05		Minimum	122.5	139.7
Damage Length (in	ches): 86	5.0		Maximum	180.5	295.9
Crush Profile Measuren	nents:	4	Std.	. Devation	26.2	65.2
	Unequal		Zone	Area	Zone	Area
	Spacing	Zone Area	Depth(x)	Depth(x)	Depth(y)	Depth(y)
C1 (inches) 0.00	(inches)	(inches²)	(inches)	(inches³)	(inches)	(inches³)
C2 (inches) 12.00	42.00	252.00	4.00	1008.00	28.00	7056.00
C3 (inches) 4.00	30.00	240.00	4.33	1040.00	42.50	10200.00
C4 (inches) 0.00	14.00	28.00	1.33	37.33	32.67	914.67
C5 (inches)						
C6 (inches)						
C7 (inches)						
C8 (inches)						
C9 (inches)						
C10 (inches)						
Average Crush (inches):	6.05					
Results			Average		KE	Closing
Results	۸	В	Force (poundsf) Er	Damage nergy (ft*lbs)	Speed Delta (mph) (mp	•
Minimum	A 122.5	139.7	41610.46	29987.07		h) (MPH) 3.4 25.9
Avg - 2 Std. Deviations	89.3	76.7	23793.41	17580.90		0.2 22.4
Avg - 2 Std. Deviations	115.5	141.9	41881.79	30018.06		3.4 26.0
Avg - 1 Std. Deviations	141.7	207.1	59970.17	42501.43		6.3 29.1
Avg + 1 Std. Deviations	167.9	272.3	78058.55	54997.82		8.8 31.9
Avg + 2 Std. Deviations	194.1	337.5	96146.93	67499.69		1.1 34.5
Maximum	180.5	295.9	84739.89	59671.23		9.7 32.9
Damage Centroid Depth (x)		4.01				42.47
Damage Centroid Depth (y)		34.94	Fff	Mass Ratio (g		1.00
Area of Damage (i	· -	520.30	LII	assao (g	u	
Aica oi Dailiage (i						

2008 GILLIG LOW FLOOR TRANSIT BUS - Front Impact

Curb Weight (pou Occupant + Cargo Weight (pou Total Weight (pou	ınds):		ver Arm Distance	_	0.00 27703.00
Angle Coll Force to Normal (deg No Damage Speed (r Energy Crush Depth (ind Damage Length (ind	mph): 5.0 ches): 1.25				
Crush Profile Measurem	Equal Spacing Zone Ar (inches) (inches		Area Depth(x) (inches³)	Zone Depth(y) (inches)	Area Depth(y) (inches³)
C1 (inches)	44.00 55.	00 0.83	45.83		806.67
Average Crush (inches): Results	1.25 A B	Average Force (poundsf) E	_	KE Speed Delta (mph) (mph	
Minimum [Avg - 2 Std. Deviations [1632.3 207.2 986.8 75.7	23793.41	28385.37		2.5 11.2
Avg - 1 Std. Deviations [Average [1641.7 209.6 2238.7 389.8	41881.79 59970.17	31898.13 35322.48		2.5 11.2
Avg + 1 Std. Deviations [Avg + 2 Std. Deviations [2790.9 605.8 3307.1 850.6	78058.55 96146.93	38678.39 41979.29		3.1 19.1 3.4 22.6
Maximum Damage Centroid Depth (x) Damage Centroid Depth (y)		84739.89 Eff	39903.48	k ² 455	20.4 5.08
Area of Damage (i			(94	, <u></u>	

2002 PONTIAC GRAND AM - Side Impact

2002 I OITIAC GIO		Side IIII	pact			
Curb Weight (po		=	PDOF Le	ver Arm Distan	ce (inches):	0.00
Occupant + Cargo Weight (po Total Weight (po	· –	<u>0</u> 50	Yaw Mo	ment of Inertia	(lb-ft-sec²)	1935.50
J .,		<u> </u>	"Known" St	tiffness Values		
Angle Coll Force to Normal (deg	, ,	0.0	Known 3	uiiness vaiues	Α	В
No Damage Speed (2.0		Average	141.7	207.1
Energy Crush Depth (in	,	<u>05</u>		Minimum	122.5	139.7
Damage Length (in	iches): 86	5.0		Maximum	180.5	295.9
Crush Profile Measurer	nents:	4	Std	I. Devation	26.2	65.2
	Unequal		Zone	Area	Zone	Area
	Spacing	Zone Area	, , ,	Depth(x)	Depth(y)	Depth(y)
C1 (inches) 0.00	(inches)	(inches²)	(inches)	(inches³)	(inches)	(inches³)
C2 (inches) 12.00	42.00	252.00		1008.00	28.00	7056.00
C3 (inches) 4.00	30.00	240.00			42.50	10200.00
C4 (inches) 0.00	14.00	28.00	1.33	37.33	32.67	914.67
C5 (inches)]		J]		
C6 (inches)]		J L			
C7 (inches)]		J [L	
C8 (inches)]		J] [
C9 (inches)]		J] [<u> </u>	
C10 (inches)]					
Average Crush (inches):	6.05					
			Average		KE	Closing
Results		Б	Force	Damage	Speed Delt	•
	A	B		inergy (ft*lbs)		ph) (MPH)
Minimum	122.5	139.7	48047.61	39982.76		25.6 28.3
Avg - 2 Std. Deviations	89.3	76.7	27474.26	23441.20		21.8 24.1
Avg - 1 Std. Deviations	115.5	141.9	48360.92	40024.07		25.7 28.3
Average	141.7	207.1	69247.58	56668.57		29.0 32.0
Avg + 1 Std. Deviations	167.9	272.3	90134.24	73330.43		32.0 35.3
Avg + 2 Std. Deviations	194.1	337.5	111020.91	89999.59		34.7 38.3
Maximum	180.5	295.9	97849.19	79561.65		36.5
Damage Centroid Depth (x		4.01				942.47
Damage Centroid Depth (y) (inches)	34.94	Ef	f. Mass Ratio (g	jamma)	1.00
Area of Damage (inches²):	520.30				

2008 GILLIG LOW FLOOR TRANSIT BUS - Front Impact

Curb Weight (pou			PDOF	ever Arm Distar	nce (inches):	0.00
ccupant + Cargo Weight (pou) Total Weight (pou			Yaw M	loment of Inertia	a (lb-ft-sec²)	28784.50
gle Coll Force to Normal (deg	rees): 0	.0				
No Damage Speed (r	nph): 5	.0				
Energy Crush Depth (inc	ches): 1.2	25				
Damage Length (inc	ches): 44	.0				
Crush Profile Measurem	ents:	2				
	Equal		Zone	Area	Zone	Area
	Spacing	Zone Area	1 , , ,	Depth(x) (inches³)	Depth(y)	Depth(y)
C1 (inches) 2.50	(inches)	(inches²) 55.00	(inches)	_ ` ´	(inches)	(inches³) 806.67
C2 (inches) 0.00	44.00	55.00		7] [
C3 (inches)			→	→]	_
C4 (inches)			J	_	J [_
C5 (inches)]	_] [
C6 (inches)]]	
C7 (inches)			J] [
C8 (inches)			J L	_]	
C9 (inches)			J	_]	
C10 (inches)						
Average Crush (inches):	1.25					
Results			Average		KE	
Results	А	В	Force (poundsf)	Damage Energy (ft*lbs)	•	lta V nph) bsub1
Minimum [1859.8	259.3	48047.61	33965.42	5.9	2.7 12.3
Avg - 2 Std. Deviations	1129.3	95.6	27474.26	29991.97	5.5	2.3 7.5
Avg - 1 Std. Deviations	1870.4	262.3	48360.92	34025.05	5.9	2.7 12.3
Average [2542.0	484.5	69247.58	37952.09	6.2	3.0 16.8
Avg + 1 Std. Deviations	3160.7	749.1	90134.24	41798.26	6.5	3.3 20.9
Avg + 2 Std. Deviations	3737.3	1047.3	111020.91	45580.11	6.8	3.6 24.7
Maximum [3378.1	855.7	97849.19	43201.96	6.7	3.4 22.3
Damage Centroid Depth (x)	(inches)	0.83			k ²	4563.01
Damage Centroid Depth (y)	(inches)	14.67	[Eff. Mass Ratio (gamma)	1.00
Area of Damage (i	nches²):	55.00				

4N6XPRT StifCalcs®

Available Test Results Side Impact Test Summary

Report Filter Settings

Year Range: 1999 - 2005

Make: PONTIAC Model: GRANDAM

Test	Vehicle	No							
Number	Info	Damage	Average		I n (dention	Lengt	h	
		Speed	Crush	KEES	S t	iffness	Value	s	Crush
		(mph)	(inch)	(mph)	Α	В	G	Kv	Factor
3527	2000 PONTIAC GRAND AM TWO DOOR COUPE	2.0	7.3	26.2	122.5	203.9	36.8	239.1	37.7
2983	1999 OLDSMOBILE ALERO FOUR DOOR SEDAN	2.0	9.4	22.2	130.2	139.7	60.7	168.7	21.0
3227	2000 PONTIAC GRAND AM TWO DOOR COUPE	2.0	8.6	26.2	133.8	188.8	47.4	221.3	32.0
3040	1999 PONTIAC GRAND AM FOUR DOOR SEDAN	2.0	7.3	26.1	180.5	295.9	55.0	347.1	37.0
		Avera	ge (AVG)		141.7	207.1	50.0	244.0	31.9
		Minim	um (MIN)		122.5	139.7	36.8	168.7	21.0
		Maximu	ım (MAX))	180.5	295.9	60.7	347.1	37.7
	Standard Deviation	on (STDev	-sample)		26.2	65.2	10.3	74.9	7.8
	N	umber of	Tests (n)	4					

Nissan Sentra into Gillig Bus Rear

2014 NISSAN SENTRA - Front Impact

Curb Weight (pour Occupant + Cargo Weight (pour Total Weight (pour Igle Coll Force to Normal (degr No Damage Speed (m Energy Crush Depth (inc	nds):	.0	Yaw M	ever Arm Distar	a (lb-ft-sec s A 402.7	2)	0.00 1716.11 B 176.1
Damage Length (inc	, <u> </u>			Minimum L Maximum	331.5 473.8		237.3
Crush Profile Measureme	Equal Spacing	Zone Area	Zone Depth(x)	Area Depth(x)	Zone Depth	e (y) [Area Depth(y)
C1 (inches) 25.00 C2 (inches) 25.00	(inches) 69.00	(inches²)		(inches ³) 21562.50	(inche	es) 4.50	(inches ³) 59512.50
C3 (inches) C4 (inches) C5 (inches)							
C6 (inches)							
C8 (inches) C9 (inches) C10 (inches)							
Average Crush (inches):	25.00						
Results	А	В	Average Force (poundsf)	Damage Energy (ft*lbs)	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)
Minimum Avg - 2 Std. Deviations	201.5	2.9	9453.00	256863.76 74428.79	52.1 28.1	56.1 31.4	
Avg - 1 Std. Deviations	302.1	89.5	87616.20	207178.87	46.8	50.8	
Average [402.7	176.1	165779.40	376965.35	63.1	67.1	73.9
Avg + 1 Std. Deviations	503.3	262.7	243942.60	547160.68	76.1	80.2	88.3
Avg + 2 Std. Deviations	603.9	349.3	322105.80	717460.78	87.1	91.4	100.6
Maximum [473.8	237.3	221017.35	497226.95	72.5	76.6	84.3
Damage Centroid Depth (x) Damage Centroid Depth (y)	(inches)	34.50 3725.00	I	Eff. Mass Ratio (k² gamma)	2804.8	00

2008 GILLIG LOW FLOOR TRANSIT BUS - Rear Impact

Curb Weight (pou Occupant + Cargo Weight (pou		0		ever Arm Distar			0.00
Total Weight (pou	ınds): 282 0	00	Yaw N	loment of Inerti	a (lb-ft-sec	<u>') </u>	7703.00
ngle Coll Force to Normal (deg	rees):	0.0					
No Damage Speed (r	nph):5	.0					
Energy Crush Depth (inc	ches): 3. 0	00					
Damage Length (inc	ches): 50	0.0					
Crush Profile Measurem	ients:	2					
	Unequal Spacing	Zone Are	1 ' '	Area Depth(x)	Zone Depth	(y) D	Area Depth(y)
C1 (inches) 6.00	(inches)	(inches ²)		(inches³)	(inche	<u> </u>	inches³)
C2 (inches) 0.00	50.00	150.00	0 2.00	300.00		6.67	2500.00
C3 (inches)				_	J		
C4 (inches)				J	J		
C5 (inches)				」 ┐┌───	J		
C6 (inches)				J L ¬ F	J		
C7 (inches)				J]		
C8 (inches)				→	J		
C9 (inches)		<u> </u>		→]		
C10 (inches)					J [
Average Crush (inches):	3.00						
Results			Average		KE	D 11 1/	
	Α	В	Force (poundsf)	Damage Energy (ft*lbs)	Speed (mph)	Delta V (mph)	bsub1
Minimum [2612.3	603.1	110538.00	71303.50	8.7	5.6	20.3
Avg - 2 Std. Deviations	346.3	10.6	9453.00	28167.06	5.5	3.2	2.7
Avg - 1 Std. Deviations	2209.9	431.6	87616.20	61986.24	8.1	5.1	17.2
Average [3459.0	1057.4	165779.40	93245.27	10.0	6.8	26.9
Avg + 1 Std. Deviations	4467.1	1763.5	243942.60	123500.02	11.5	8.1	34.7
Avg + 2 Std. Deviations	5335.8	2516.2	322105.80	153174.04	12.8	9.2	41.5
Maximum [4188.8	1550.6	221017.35	114698.65	11.0	7.7	32.6
Damage Centroid Depth (x)	(inches)	2.00			k ²	4555.0	8
Damage Centroid Depth (y)	(inches)	16.67		Eff. Mass Ratio (gamma)	1.0	0
Area of Damage (i	nches²):	150.00					

4N6XPRT StifCalcs®

Available Test Results Front Impact Test Summary

Report Filter Settings

Year Range: 2013 - 2015

Make: NISSAN Model: SENTRA

Test	Vehicle	No							
Number	Info	Damage	Average		\	/ehicle	Width		
		Speed	Crush	KEES	S t	iffness	Value	s	Crush
		(mph)	(inch)	(mph)	Α	В	G	Kv	Factor
9079	2015 NISSAN SENTRA FOUR DOOR SEDAN	5.0	17.4	35.2	331.5	114.9	478.4	156.0	28.4
8068	2013 NISSAN SENTRA FOUR DOOR SEDAN	5.0	11.9	34.9	473.8	237.3	473.0	323.3	40.8
		Avera	ge (AVG)		402.7	176.1	475.7	239.6	34.6
		Minim	um (MIN)		331.5	114.9	473.0	156.0	28.4
		Maximu	ım (MAX))	473.8	237.3	478.4	323.3	40.8
	Standard Deviati	on (STDev	-sample)		100.6	86.6	3.8	118.3	8.7
	N	lumber of	Tests (n)	2					

Chevrolet Malibu into Gillig Bus Rear Axle

2004 CHEVROLET MALIBU - Front Impact

Curb Weight (pounds): 3262 Occupant + Cargo Weight (pounds): 0	PDOF Lever Arm Dist		0.00
Total Weight (pounds): 3262	Yaw Moment of Iner	tia (lb-ft-sec²)	2153.86
ngle Coll Force to Normal (degrees): 0.0	"Known" Stiffness Valu	l es A	В
No Damage Speed (mph): 5.0	Average	375.1	131.5
Energy Crush Depth (inches): 33.63	Minimum	291.3	86.7
Damage Length (inches): 43.0	Maximum	496.8	232.8
	Std. Devation	52.3	38.2
Crush Profile Measurements:3			
Unequal Spacing Zone Area	Zone Area Depth(x) Depth(x)	Zone Depth(y)	Area Depth(y)
(inches) (inches²)	(inches) (inches ³)		(inches ³)
C1 (inches) 25.00 23.00 736.00	16.26 11963.8	12.34	9081.17
C2 (inches) 39.00 20.00 710.00	17.81 12643.3	29.67	21066.67
C3 (inches) 32.00			
C4 (inches)		 	
C5 (inches)			
C6 (inches)]		
C7 (inches)]	_	
C8 (inches)		_	
C9 (inches)		_	
C10 (inches)			
·			
Average Crush (inches): 33.63			
Average Crush (inches): 33.63	Average	KE	Closing
Average Crush (inches): 33.63 Results	Average Force Damage	KE Speed Delta	•
Results A B	Force Damage (poundsf) Energy (ft*lbs	Speed Delta) (mph) (mp	a V Speed h) (MPH)
Results	Force Damage	Speed Delta) (mph) (mp	a V Speed
Results	Force Damage (poundsf) Energy (ft*lbs	Speed Delta) (mph) (mp 44.4 4	a V Speed h) (MPH)
Results A B Minimum 291.3 86.7	Force Damage (poundsf) Energy (ft*lbs	Speed Delta) (mph) (mp 3 44.4 4 7 36.9 3	a V Speed (h) (MPH) 4.1 49.3
Results A B Minimum 291.3 86.7 Avg - 2 Std. Deviations 270.5 55.1	Force Damage (poundsf) Energy (ft*lbs 214655.23 45655.53 147971.47	Speed Delta) (mph) (mp 3 44.4 4 7 36.9 3 8 46.2 4	a V Speed (h) (MPH) 4.1 49.3 6.7 40.9
Results A B Minimum 291.3 86.7 Avg - 2 Std. Deviations 270.5 55.1 Avg - 1 Std. Deviations 322.8 93.3	Force Damage (poundsf) Energy (ft*lbs 45655.53 147971.47 74400.30 232233.43	Speed Delta (mph) (mp 3 44.4 4 7 36.9 3 8 46.2 4 9 54.0 5	A V Speed (MPH) 4.1 49.3 6.7 40.9 5.9 51.2
Results A B Minimum 291.3 86.7 Avg - 2 Std. Deviations 270.5 55.1 Avg - 1 Std. Deviations 322.8 93.3 Average 375.1 131.5	Force Damage (poundsf) Energy (ft*lbs 45655.53 147971.47 74400.30 232233.43 103145.07 316789.70	Speed Delta) (mph) (mp 3 44.4 4 7 36.9 3 8 46.2 4 0 54.0 5 1 60.8 6	A V Speed (MPH) 4.1 49.3 6.7 40.9 5.9 51.2 3.6 59.8
Results A B Minimum 291.3 86.7 Avg - 2 Std. Deviations 270.5 55.1 Avg - 1 Std. Deviations 322.8 93.3 Average 375.1 131.5 Avg + 1 Std. Deviations 427.4 169.7	Force Damage (poundsf) Energy (ft*lbs 68950.95 214655.23 45655.53 147971.47 74400.30 232233.43 103145.07 316789.70 131889.84 401441.52	Speed Delta) (mph) (mp 3 44.4 4 3 36.9 3 4 46.2 4 5 54.0 5 6 60.8 6 6 66.9 6	A V Speed (MPH) 4.1 49.3 6.7 40.9 5.9 51.2 3.6 59.8 0.3 67.3
Results A B Minimum 291.3 86.7 Avg - 2 Std. Deviations 270.5 55.1 Avg - 1 Std. Deviations 322.8 93.3 Average 375.1 131.5 Avg + 1 Std. Deviations 427.4 169.7 Avg + 2 Std. Deviations 479.7 207.9	Force Damage (poundsf) Energy (ft*lbs 68950.95 214655.23 45655.53 147971.47 74400.30 232233.43 103145.07 316789.70 131889.84 401441.52 160634.61 486136.23	Speed Delta) (mph) (mp 3 44.4 4 3 36.9 3 4 46.2 4 5 40.0 55 6 60.8 6 7 70.4 6	A V Speed (MPH) 4.1 49.3 6.7 40.9 5.9 51.2 3.6 59.8 0.3 67.3 6.3 74.0
Results A B Minimum 291.3 86.7 Avg - 2 Std. Deviations 270.5 55.1 Avg - 1 Std. Deviations 322.8 93.3 Average 375.1 131.5 Avg + 1 Std. Deviations 427.4 169.7 Avg + 2 Std. Deviations 479.7 207.9 Maximum 496.8 232.8	Force Damage (poundsf) Energy (ft*lbs 68950.95 214655.23 45655.53 147971.47 74400.30 232233.43 103145.07 316789.70 131889.84 401441.52 160634.61 486136.23	Speed Delta) (mph) (mp 3 44.4 4 7 36.9 3 8 46.2 4 9 54.0 5 9 60.8 6 8 66.9 6 k² 30	A V Speed (MPH) 4.1 49.3 6.7 40.9 5.9 51.2 3.6 59.8 0.3 67.3 6.3 74.0 9.9 78.0

2008 GILLIG LOW FLOOR TRANSIT BUS - Side Impact

Curb Weight (pou Occupant + Cargo Weight (pou Total Weight (pou	nds):	0		ever Arm Distar			0.00
Angle Coll Force to Normal (degi No Damage Speed (r Energy Crush Depth (inc Damage Length (inc	nph): 1 :hes): 2.5						
Crush Profile Measurem C1 (inches) 0.00	ents: Unequal Spacing (inches)	Zone Area (inches²)	1 ' '	Area Depth(x) (inches³)	Zone Depth((inche	(y) D	Area epth(y) nches³)
C2 (inches) 5.00 C3 (inches) 0.00	20.00	97.50 50.00				5.67	2535.00 1333.33
C4 (inches) C5 (inches) C6 (inches)							
C7 (inches) C8 (inches) C9 (inches)							
C10 (inches)Average Crush (inches):	2.50		Average		KE		
Results	А	В	Force (poundsf)	Damage Energy (ft*lbs)	Speed (mph)	Delta V (mph)	bsub1
Minimum [527.0	724.1	68950.95	22255.26	4.9	5.1	24.2
Avg - 2 Std. Deviations	416.6	452.4	45655.53	15331.81	4.0	4.2	19.1
Avg - 1 Std. Deviations	659.7	788.8	74400.30 103145.07	23863.34 32297.33	5.0	6.2	30.3
Average $\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	755.0	1486.3	131889.84	40672.58	6.6	7.0	34.6
Avg + 2 Std. Deviations	840.5	1841.9	160634.61	49007.45	7.2	7.7	38.6
Maximum [891.2	2070.7	179006.08	54318.30	7.6	8.1	40.9
Damage Centroid Depth (x) Damage Centroid Depth (y)		1.67 26.23		Eff. Mass Ratio (k²	4555.08	_
Area of Damage (ii		147.50	•		gaa) I	_,,,,	

2004 CHEVROLET MALIBU - Front Impact

2004 CHEVROLLI IV	IALIDO		pact				
Curb Weight (pour Occupant + Cargo Weight (pour		62 0		ver Arm Distan	,	0.00	
Total Weight (pour	nds): 32 0	62	Yaw Mo	ment of Inertia	(lb-ft-sec²)	2153.86	
Angle Coll Force to Normal (degr	ees):	0.0	"Known" St	tiffness Values	A	В	7
No Damage Speed (m	nph): 5	5.0		Average	375.1	131.5	
Energy Crush Depth (inc	hes): 33. 6	63		Minimum _	291.3	86.7	
Damage Length (inc	hes): 43	3.0		Maximum	496.8	232.8	
			Sto	I. Devation	52.3	38.2	
Crush Profile Measureme		3					╛
	Unequal Spacing	Zone Area	Zone Depth(x)	Area Depth(x)	Zone Depth(y)	Area Depth(y)	
	(inches)	(inches²)	(inches)	(inches³)	(inches)	(inches³)	
C1 (inches) 25.00	23.00	736.00	16.26	11963.83	12.34	9081.17]
C2 (inches) 39.00	20.00	710.00	17.81	12643.33	29.67	7 21066.67	_
C3 (inches) 32.00			1] [_
C4 (inches)		Γ] [) [] [_	ユ コ
C5 (inches)]	1		_	_
C6 (inches)] [_ _
C7 (inches)] [_	
C8 (inches)							
C9 (inches)] [L
C10 (inches)]
Average Crush (inches):	33.63						
- Average Crush (inches).	33.03		Average		KE	Closing	
Results			Average Force	Damage		Closing elta V Speed	
	Α	В		inergy (ft*lbs)	•	mph) (MPH)	
Minimum [291.3	86.7	68950.95	214655.23	44.4	40.3 54.0	
Avg - 2 Std. Deviations	270.5	55.1	45655.53	147971.47	36.9	33.4 44.8	
Avg - 1 Std. Deviations	322.8	93.3	74400.30	232233.43	46.2	41.9 56.1]
Average [375.1	131.5	103145.07	316789.70	54.0	48.9 65.5]
Avg + 1 Std. Deviations	427.4	169.7	131889.84	401441.52	60.8	55.0 73.7]
Avg + 2 Std. Deviations	479.7	207.9	160634.61	486136.23	66.9	60.5 81.1	
Maximum [496.8	232.8	179006.08	539176.36	70.4	63.8 85.4]
Damage Centroid Depth (x)	(inches)	17.02			k ²	3061.62	
Damage Centroid Depth (y)	(inches)	20.85	Ef	f. Mass Ratio (g	jamma)	1.00	
Area of Damage (in	nches²):	1446.09					

2008 GILLIG LOW FLOOR TRANSIT BUS - Side Impact

Curb Weight (pou Occupant + Cargo Weight (pou Total Weight (pou	nds):			ever Arm Distan		94.00
Angle Coll Force to Normal (degr No Damage Speed (n Energy Crush Depth (inc Damage Length (inc	nph): 1.0					
Crush Profile Measurem	Unequal	Zone Area (inches²)	Zone Depth(x) (inches)	Area Depth(x) (inches³)	Zone Depth(y) (inches)	Area Depth(y) (inches³)
C1 (inches)	2.50	97.50	1.67 1.67		26.00 26.67	2535.00 1333.33
Results	A 527.0		<u> </u>	Damage Energy (ft*lbs)	KE Speed Delta (mph) (mp	oh) bsub1
Minimum $\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$	527.0 416.6	724.1 452.4	45655.53	22255.26 15331.81	4.9	4.7 24.2 3.9 19.1
Avg - 1 Std. Deviations	550.0	788.8	74400.30	23863.34		4.8 25.2
Average	659.7	1134.7	103145.07	32297.33	5.9	5.7 30.3
Avg + 1 Std. Deviations	755.0	1486.3	131889.84	40672.58	6.6	6.4 34.6
Avg + 2 Std. Deviations	840.5	1841.9	160634.61	49007.45	7.2	7.0 38.6
Maximum [891.2	2070.7	179006.08	54318.30	7.6	7.4 40.9
Damage Centroid Depth (x)	(inches)	1.67			k ² 45	55.08
Damage Centroid Depth (y)	(inches)	26.23	E	eff. Mass Ratio (g	jamma)	0.34
Area of Damage (ir	nches²):	.47.50				

4N6XPRT StifCalcs®

Available Test Results Front Impact Test Summary

Report Filter Settings

Year Range: 2004 - 2007 Make: CHEVROLET Model: MALIBU

Test Number	Vehicle Info	No Damage Speed (mph)	Average Crush (inch)			Vehicle iffness B			Crush Factor
5183	2004 SAAB 9-3 FOUR DOOR SEDAN	5.0	16.5	29.5	291.3	86.7	489.2	125.7	21.2
6056	2007 SAAB 9-3 FOUR DOOR SEDAN	5.0	19.4	34.7	334.5	102.4	546.6	139.8	24.8
5191	2004 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	16.4	29.7	341.3	102.7	567.0	148.5	21.5
6448	2008 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	11.9	24.7	360.3	119.2	544.3	187.3	20.5
6998	2011 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	18.6	35.1	360.9	117.1	556.0	159.3	26.6
5851	2006 SAAB 9-3 FOUR DOOR SEDAN	5.0	11.3	24.7	364.5	126.8	524.0	199.1	21.6
5271	2005 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	18.4	35.0	366.4	119.1	563.3	162.2	26.5
4863	2004 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	17.0	35.5	371.3	133.4	516.8	180.7	29.7
6268	2008 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	17.7	34.9	378.9	128.0	560.7	174.5	27.5
5250	2005 PONTIAC G6 FOUR DOOR SEDAN	5.0	17.0	35.3	393.2	139.8	552.9	189.7	29.2
5844	2007 SATURN AURA FOUR DOOR SEDAN	5.0	15.6	35.1	442.4	170.2	574.9	231.5	31.5
6997	2011 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	6.4	20.1	496.8	232.8	530.2	412.8	25.0
		Avera	ge (AVG)		375.1	131.5	543.8	192.6	25.5
		Minim	um (MIN))	291.3	86.7	489.2	125.7	20.5
		Maximu	ım (MAX)	496.8	232.8	574.9	412.8	31.5
	Standard Deviation	on (STDev	-sample))	52.3	38.2	24.7	75.0	3.7

Number of Tests (n) 12

Pontiac Montana Extended into Ford F600 Rear

2001 PONTIAC MONTANA EXTENDED - Front Impact

Curb Weight (pou		=	PDOF	ever Arm Distar	nce (inches)	:	0.00
Occupant + Cargo Weight (pour	· -	0		loment of Inertia			2717.26
Total Weight (pou	nas): [394	+2				,	
ngle Coll Force to Normal (degr	ees): 0	.0	"Known"	Stiffness Values	s A		В
No Damage Speed (n	nph): 5	.0		Average _	351.4		104.5
Energy Crush Depth (inc	hes): 29.0	00		Minimum	303.0		79.1
Damage Length (inc	hes): 72	.0		Maximum _	470.0		183.8
Crush Profile Measurem	onts:	2	St	td. Devation	56.9		35.9
Crush Frome Measurem	Unequal		Zone	Area	Zone	<u> </u>	 Area
	Spacing	Zone Area		Depth(x)	Depth		epth(y)
C1 (inches) 29.00	(inches)	(inches²)	(inches)	(inches³)	(inche	es) (i	inches³)
C2 (inches) 29.00	72.00	2088.00	14.50	30276.00	36	5.00	75168.00
C3 (inches)							
C4 (inches)							
C5 (inches)							
C6 (inches)							
C7 (inches)							
C8 (inches)							
C9 (inches)							
C10 (inches)							
Average Crush (inches):	29.00						
Results			Average	D	KE	Dalta V	Closing
	Α	В	Force (poundsf)	Damage Energy (ft*lbs)	Speed (mph)	Delta V (mph)	Speed (MPH)
Minimum [303.0	79.1	93488.40	255773.31	44.1	38.3	52.6
Avg - 2 Std. Deviations	237.6	32.7	42692.40	129023.74	31.3	27.2	37.3
Avg - 1 Std. Deviations	294.5	68.6	82220.40	228113.67	41.7	36.2	49.6
Average [351.4	104.5	121748.40	328342.04	50.0	43.4	59.5
Avg + 1 Std. Deviations	408.3	140.4	161276.40	428835.56	57.1	49.6	68.0
Avg + 2 Std. Deviations	465.2	176.3	200804.40	529432.25	63.5	55.1	75.6
Maximum	470.0	183.8	208807.20	549112.95	64.6	56.2	77.0
Damage Centroid Depth (x)		14.50			k ²	3196.19	_
Damage Centroid Depth (y)		36.00	ĺ	Eff. Mass Ratio (1.00	_
Area of Damage (ir		2088.00		(٠ · · ·		

1978 FORD F600 - Rear Impact

Curb Weight (pour Occupant + Cargo Weight (pour Total Weight (pour	nds):	0		ever Arm Distan	· · · · · · · · · · · · · · · · · · ·	9611.05
Angle Coll Force to Normal (degr No Damage Speed (n Energy Crush Depth (inc Damage Length (inc	nph): 1. 0	0				
Crush Profile Measurement C1 (inches)	Unequal Spacing (inches) 96.00	Zone Area (inches²) 96.00	(inches)	Area Depth(x) (inches³) 48.00	Zone Depth(y) (inches) 48.00	Area Depth(y) (inches³) 4608.00
Average Crush (inches): Results	1.00		Average Force	Damage	KE Speed Delt	
ь a:	A 374.0	1573.6	(poundsf) 93488.40	Energy (ft*lbs) 9642.42	(mph) (mp	oh) bsub1 14.2 74.0
Minimum L Avg - 2 Std. Deviations	240.2	649.2	42692.40	4874.25		14.2 74.0
Avg - 1 Std. Deviations	348.3	1364.6	82220.40	8600.52		13.4 69.0
Average	432.5	2103.9	121748.40	12231.23		85.6
Avg + 1 Std. Deviations	503.9	2856.0	161276.40	15810.85	6.7	99.8
Avg + 2 Std. Deviations	567.0	3616.4	200804.40	19357.34	7.4	20.4 112.3
Maximum [579.0	3771.1	208807.20	20072.25	7.5	20.8 114.6
Damage Centroid Depth (x)	(inches)	0.50			k ² 41	90.36
Damage Centroid Depth (y)	(inches)	48.00	E	Eff. Mass Ratio (gamma)	1.00
Area of Damage (ir	iches²):	96.00				

4N6XPRT StifCalcs®

Available Test Results Front Impact Test Summary

Report Filter Settings

Year Range: 1999 - 2004

Make: PONTIAC Model: MONTANA

Test Number	Vehicle Info	No Damage Speed (mph)	Average Crush (inch)			Vehicle iffness B			Crush Factor
2963	1998 CHEVROLET VENTURE VAN	5.0	25.1	37.8	303.0	79.1	579.9	105.1	22.7
2552	1997 CHEVROLET VENTURE VAN	5.0	23.2	35.3	311.2	81.2	596.6	110.2	21.5
5087	2001 CHEVROLET VENTURE MINIVAN	5.0	22.3	35.0	316.4	85.0	588.4	115.8	21.9
3070	1998 CHEVROLET VENTURE VAN	5.0	18.3	29.8	323.7	87.7	597.5	126.7	19.4
2895	1998 CHEVROLET VENTURE VAN	5.0	17.6	29.0	339.7	92.8	622.1	135.4	19.1
2750	1998 CHEVROLET VENTURE VAN	5.0	21.7	35.1	346.5	96.3	622.9	131.0	22.8
2902	1998 CHEVROLET VENTURE VAN	5.0	20.0	37.5	401.0	130.4	616.5	173.6	28.2
3676	2001 CHEVROLET VENTURE MINIVAN	5.0	15.2	34.7	470.0	183.8	601.0	250.9	31.7
		Averaç	ge (AVG)		351.4	104.5	603.1	143.6	23.4
		Minim	um (MIN))	303.0	79.1	579.9	105.1	19.1
		Maximu	ım (MAX)	470.0	183.8	622.9	250.9	31.7
	Standard Deviation	on (STDev	-sample))	56.9	35.9	15.9	48.3	4.3
	N	umber of	Tests (n)	8					

Chevrolet Malibu into Ford F600 Rear Axle

2004 CHEVROLET MALIBU - Front Impact

Curb Weight (pou Occupant + Cargo Weight (pou Total Weight (pou	ınds):	0		ever Arm Distan			0.00	
Angle Coll Force to Normal (degr No Damage Speed (r Energy Crush Depth (inc Damage Length (inc	nph): 5.	2	"Known" S	Average Minimum Maximum	A 376.9 291.3 496.8		B 132.7 86.7 232.8	
Crush Profile Measurem	ents: Unequal Spacing (inches)	Zone Area (inches²)	Zone Depth(x) (inches)	d. Devation Area Depth(x) (inches³)	Zone Depth((inche	e (y) [Area Depth(y) (inches³)	
C1 (inches)	25.00 18.00	324.00	9.23		-	2.59	7083.33 8478.00	
C7 (inches) C8 (inches) C9 (inches) C10 (inches) Average Crush (inches):	20.62							
Results Minimum	A 291.3	B 86.7	Average Force (poundsf)	Damage Energy (ft*lbs) 90611.55	KE Speed (mph)	Delta V (mph)	Closing Speed (MPH)	
Avg - 2 Std. Deviations Avg - 1 Std. Deviations	272.1 324.5	56.7 94.7	30986.96 48960.10	99516.30	24.7	27.4 31.7	35.8	
Average L Avg + 1 Std. Deviations Avg + 2 Std. Deviations	376.9 429.3 481.7	132.7 170.7 208.7	84906.38 102879.52	132826.95 166228.30 199670.81	35.0 39.1 42.9	35.4 38.9 42.0	50.8 54.9	
Maximum Damage Centroid Depth (x) Damage Centroid Depth (y) Area of Damage (ii	(inches)	232.8 10.51 17.55 886.50	113888.42	219411.83 Eff. Mass Ratio (k ² gamma)	3061.6 1.0	2	

1978 FORD F600 - S	ide Imp	act					
Curb Weight (pou	ınds): 10 0	635	PDOF	ever Arm Distan	ice (inches):	0.00
Occupant + Cargo Weight (pou		0		oment of Inerti			9611.05
Total Weight (pou	inds): [100	635			(10 10 500	,	
Angle Coll Force to Normal (degi	rees):	0.0					
No Damage Speed (r	mph): 1	LO.0					
Energy Crush Depth (inc	ches):	L.00					
Damage Length (in	ches): 4	15.0					
Crush Profile Measurem	ients:	2					
	Equal		Zone	Area	Zone		Area
	Spacing	Zone Area		Depth(x)	Depth	•	epth(y)
C1 (inches) 1.00	(inches)	(inches²)		(inches³)	(inche		inches³)
C2 (inches) 1.00	45.00	45.00	0.50	22.50]	2.50	1012.50
C3 (inches)		_	_	_	J		
C4 (inches)		J	_	_	J	_	
C5 (inches)		J	_	_	J		
C6 (inches)]	_	_	J	-	
C7 (inches)		J L	_	_	J	-	
C8 (inches)			_	_	J		
C9 (inches)			_	J	J		
C10 (inches)					J [
Average Crush (inches):	1.00						
Dogulta			Average		KE		
Results			Force	Damage	Speed	Delta V	
Г	A	B	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	bsub1
Minimum L	1813.3	173.4	44699.66	42685.09	11.0	9.4	16.8
Avg - 2 Std. Deviations	1289.5	87.7	30986.96	40560.30	10.7	8.4	12.0
Avg - 1 Std. Deviations	1971.1	204.9	48960.10	43336.10	11.1	9.7	18.3
Average L	2614.4	360.4	66933.24	46040.00	11.4	10.9	24.3
Avg + 1 Std. Deviations	3225.2	548.5	84906.38	48682.92	11.7	11.9	29.9
Avg + 2 Std. Deviations	3807.9	764.5	102879.52	51273.27	12.0	12.9	35.3
Maximum	4152.5	909.2	113888.42	52836.87	12.2	13.4	38.5

Eff. Mass Ratio (gamma)

0.50

22.50

45.00

Damage Centroid Depth (x) (inches)

Damage Centroid Depth (y) (inches)

Area of Damage (inches²):

1.00

4190.36

2004 CHEVROLET MALIBU - Front Impact

Curb Weight (pounds): 3262	PDOF Lever Arm	Distance (inches)	0.00
Occupant + Cargo Weight (pounds): 0		f Inertia (lb-ft-sec	
Total Weight (pounds): 3262	Tuw Woment of	Tiricitia (ib 10 300	7 =======
Angle Coll Force to Normal (degrees): 0.0	"Known" Stiffness \		D
No Damage Speed (mph): 5.0	Averag	A ae 376.9	B 132.7
Energy Crush Depth (inches): 20.62		,	86.7
Damage Length (inches): 43.0	Minimu Maximu		232.8
	Std. Devatio		38.0
Crush Profile Measurements: 3		<u></u>	
Unequal Spacing Zone Area	Zone Are		
Spacing Zone Area (inches) (inches²)	Depth(x) Dept (inches) (inch	h(x) Depth(nes ³) (inche	•
C1 (inches) 22.00 25.00 562.50			2.59 7083.33
C2 (inches) 23.00 18.00 324.00			6.17 8478.00
C3 (inches) 13.00		752.00	. <u></u>
C4 (inches)			
C5 (inches)			
C6 (inches)			
C7 (inches)			
C8 (inches)			
C9 (inches)			
C10 (inches)			
Average Crush (inches): 20.62			
	Average	KE	Closing
Results	Force Damag		Delta V Speed
A B	(poundsf) Energy (ft	:*lbs) (mph)	(mph) (MPH)
Minimum 291.3 86.7	44699.66 9061	1.55 28.9	26.8 45.7
Avg - 2 Std. Deviations 272.1 56.7	30986.96 6647	8.72 24.7	24.0 41.0
Avg - 1 Std. Deviations 324.5 94.7	48960.10 9951	6.30 30.3	27.7 47.3
Average 376.9 132.7	66933.24 13282	6.95 35.0	31.0 52.9
Avg + 1 Std. Deviations 429.3 170.7	84906.38 16622	8.30 39.1	34.0 58.0
Avg + 2 Std. Deviations 481.7 208.7	102879.52 19967	0.81 42.9	36.7 62.7
Maximum 496.8 232.8	113888.42 21941	1.83 44.9	38.3 65.3
Damage Centroid Depth (x) (inches) 10.51		k² [3061.62
Damage Centroid Depth (y) (inches) 17.55	Eff. Mass R	Ratio (gamma) [1.00
Area of Damage (inches²): 886.50			

1978 FORD F600 -	Side Imp	act					
Curb Weight (po	PDOF	PDOF Lever Arm Distance (inches):					
ccupant + Cargo Weight (po Total Weight (po		0 635	Yaw N	Yaw Moment of Inertia (lb-ft-sec²)			
gle Coll Force to Normal (deg No Damage Speed Energy Crush Depth (ir Damage Length (in	(mph): 1 nches): 1 nches): 4	0.0 10.0 1.00					
Crush Profile Measurer		2	-		7		
	Equal Spacing	Zone Area	1 , ,	Area Depth(x)	Zone Depth(y)	Area Depth(y)	
C1 (inches) 1.00	(inches)	(inches ²)		(inches³)	(inches)	(inches³)	
C2 (inches) 1.00	45.00	45.00	0.50	22.50	22.50	1012.50	
C3 (inches)	ī			_			
C4 (inches)	ī		_				
C5 (inches)]						
C6 (inches)	,						
C7 (inches)	,						
	,						
C8 (inches)	,						
C9 (inches)	<u> </u>						
C10 (inches)]						
Average Crush (inches):	1.00						
Results			Average Force	Damage	KE Speed Delta	a V	
	Α	В	(poundsf)	Energy (ft*lbs)	(mph) (mp	oh) bsub1	
Minimum	1813.3	173.4	44699.66	42685.09	11.0	8.2 16.8	
Avg - 2 Std. Deviations	1289.5	87.7	30986.96	40560.30	10.7	7.4 12.0	

Dagulta			Average	Average KE			
Results			Force	Damage	Speed	Delta V	
	Α	В	(poundsf)	Energy (ft*lbs)	(mph)	(mph)	bsub1
Minimum	1813.3	173.4	44699.66	42685.09	11.0	8.2	16.8
Avg - 2 Std. Deviations	1289.5	87.7	30986.96	40560.30	10.7	7.4	12.0
Avg - 1 Std. Deviations	1971.1	204.9	48960.10	43336.10	11.1	8.5	18.3
Average	2614.4	360.4	66933.24	46040.00	11.4	9.5	24.3
Avg + 1 Std. Deviations	3225.2	548.5	84906.38	48682.92	11.7	10.4	29.9
Avg + 2 Std. Deviations	3807.9	764.5	102879.52	51273.27	12.0	11.3	35.3
Maximum	4152.5	909.2	113888.42	52836.87	12.2	11.7	38.5
Damage Centroid Depth (x) (inches)	0.50			k^2	4190.36	
Damage Centroid Depth (y) (inches)	22.50		Eff. Mass Ratio (gamma)	0.43	
Area of Damage	(inches²):	45.00					

4N6XPRT StifCalcs®

Available Test Results Front Impact Test Summary

Report Filter Settings

Year Range: 2004 - 2007 Make: CHEVROLET Model: MALIBU

Test Number	Vehicle Info	No Damage Speed (mph)	Average Crush (inch)			Vehicle iffness B			Crush Factor
5183	2004 SAAB 9-3 FOUR DOOR SEDAN	5.0	16.5	29.5	291.3	86.7	489.2	125.7	21.2
6056	2007 SAAB 9-3 FOUR DOOR SEDAN	5.0	19.4	34.7	334.5	102.4	546.6	139.8	24.8
5191	2004 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	16.4	29.7	341.3	102.7	567.0	148.5	21.5
6448	2008 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	11.9	24.7	360.3	119.2	544.3	187.3	20.5
6998	2011 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	18.6	35.1	360.9	117.1	556.0	159.3	26.6
5851	2006 SAAB 9-3 FOUR DOOR SEDAN	5.0	11.3	24.7	364.5	126.8	524.0	199.1	21.6
5271	2005 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	18.4	35.0	366.4	119.1	563.3	162.2	26.5
4863	2004 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	17.0	35.5	371.3	133.4	516.8	180.7	29.7
6268	2008 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	17.7	34.9	378.9	128.0	560.7	174.5	27.5
5250	2005 PONTIAC G6 FOUR DOOR SEDAN	5.0	17.0	35.3	393.2	139.8	552.9	189.7	29.2
5844	2007 SATURN AURA FOUR DOOR SEDAN	5.0	15.6	35.1	442.4	170.2	574.9	231.5	31.5
6997	2011 CHEVROLET MALIBU FOUR DOOR SEDAN	5.0	6.4	20.1	496.8	232.8	530.2	412.8	25.0
		Average (AVG)			375.1	131.5	543.8	192.6	25.5
	Minimum (MIN)				291.3	86.7	489.2	125.7	20.5
	Maximum (MAX)				496.8	232.8	574.9	412.8	31.5
Standard Deviation (STDev-sample)					52.3	38.2	24.7	75.0	3.7

Number of Tests (n) 12