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June 1987

Final Report

CRASH III Model Improvements: Derivation of New Side Stiffness Parameters from Crash Tests, Volume 2

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16. Abstract

The CRASH III computer model uses physical evidence, such as various vehicle parameters and vehicle damage measurements, to reconstruct highway accidents. When damage measurements are used in a reconstruction, the model assumes a set of stiffness parameters which represent the resistance to crush for a group of vehicles. The set of parameters assumed is dependent on both the type of impact (frontal, side, or rear) and the type of vehicle(s) in the reconstruction. In the current model, stiffness parameters for passenger cars are categorized by wheelbase.

This report is divided into two volumes. Reported in this volume, Volume II, are the results of a study done to derive new side stiffness parameters for the CRASH III model. Eleven side impact crash tests were done to obtain the crush measurements necessary to derive these parameters.

Four vehicle models were tested. Occupant compartment impacts at two different impact speeds were done on each to derive stiffness parameters for these vehicles. One of these models was re-tested at a third speed to determine if the derived stiffness parameters were velocity sensitive. This same model was also used in non-compartment impacts, again at two speeds, to explore any impact location sensitivity. The results of these investigations are presented.

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Department of Transportation
National Highway Traffic Safety Administration

TECHNICAL SUMMARY

Report Title Crash III Model Improvements: Derivation of New Side Stiffness Parameters from Crash Tests, Volume 2	June 1987

Report Author(s)

Donald T. Willke and Michael W. Monk

The CRASH III computer model was developed for use in highway accident reconstruction. The model uses physical evidence such as various vehicle parameters, vehicle trajectory information, and vehicle damage measurements. The primary outputs of the model are the vector changes in velocity (Δv) of the vehicles resulting from the collision and impact speeds (only if trajectory information is available).

When damage measurements are used in a reconstruction, the model assumes a set of stiffness parameters which represent the resistance to crush for a group of vehicles. The set of parameters is dependent on both the impact mode (frontal, side, or rear) and the type of vehicle(s) in the reconstruction. In the current model, stiffness parameters for passenger cars are categorized according to wheelbase.

This report is divided into two volumes. Reported in this volume, Volume II, are the results of a study done to derive new side stiffness parameters for the CRASH III model. Eleven side impact crash tests were done to obtain the crush measurements necessary to derive these parameters.

Four vehicle models were tested. These were the Ford Escort, the Mitsubishi Tredia, the Chevrolet Citation, and the Ford LTD. Two occupant compartment impacts were done on each, using a low and a high impact speed. These resulted in Δv's of 10 and 20 mph, respectively, on the subject car. From each pair of tests, a set of stiffness parameters was derived. These were compared to the side stiffness parameters currently used in the model.

A third crash test was performed on a Citation, with an impact speed resulting in a Δv of 25 mph. When paired with the previous low speed test results for that car, a second set of Citation stiffness parameters was derived. This enabled a determination to be made as to whether or not there was velocity sensitivity in the parameters derived. The Citation was also used in low and high speed non-occupant compartment crash tests. This allowed a comparison between the stiffness parameters found from striking the car in different locations.

CRASH III MODEL IMPROVEMENTS:

Derivation of New Side Stiffness Parameters From Crash Tests

1.0 INTRODUCTION

The CRASH III* computer program was developed for use in highway accident reconstruction. The model uses physical evidence such as various vehicle parameters, vehicle trajectory information, and vehicle damage measurements. In the absence of trajectory measurements, the reconstruction is based solely on vehicle damage measurements, and vice versa. In the absence of both trajectory and damage measurements, reconstruction is based solely on the Collision Damage Classification (CDC). The primary outputs of the model are the vector changes in velocity (ΔV) of the vehicle(s) resulting from the collision and impact speeds (only if trajectory information is available).

When damage measurements are used in a reconstruction, the model assumes a set of stiffness parameters which represent the resistance to crush for a group of vehicles. The set of parameters assumed is dependent on both the impact mode (frontal, side, or rear) and the type of vehicle(s) in the reconstruction. In the current model, stiffness parameters for passenger cars are categorized according to wheelbase.

For each impact mode, stiffness parameters were derived from crash test data. The side parameters currently in the model are based on very little data due to a lack of appropriate crash tests in this mode. A portion of this effort was to perform nine occupant compartment crash tests and two non-compartment impacts from which the resulting data could be used to derive side stiffness parameters. This report presents the data from these tests as well as the parameters found.

* Calspan Reconstruction of Accident Speeds on the Highway, Version 3

2.0 OBJECTIVE

The purposes of this study were to derive new side stiffness parameters for use in the CRASH III model, and to examine the sensitivity of those parameters to variations in test and measurement procedures. Stiffness parameters were obtained by designing and conducting a side impact crash test program, measuring crush values, and performing the necessary calculations.

3.0 TEST PROCEDURES

3.1 Test Conditions

Prior to conducting the crash tests, it was necessary to select the vehicles and define the conditions for each test. These conditions included impact velocity, location, and angle as well as the type and size of striking vehicle to be used.

Four passenger cars were selected, one in each of the four shortest wheelbase categories. They were the Ford Escort, the Mitsubishi Tredia, the Chevrolet Citation, and the Ford LTD.

It was judged that half of the crash tests should be done at a relatively low speed ($\Delta V \approx 10$ mph) while the others should be performed at a higher speed ($\Delta V \approx 20$-25 mph). In the study of Reference 1, frontal and rear stiffness parameters were calculated based on crash tests performed at higher speeds only. During that study, it was found that these did a poor job of predicting the velocity changes of low severity collisions. Consequently, they were adjusted such that the lower speed collisions could be more accurately modelled. The adjusted parameters are those currently used in the CRASH III model. It was felt that this type of adjustment would not be necessary if the parameters were derived from both low and high speed crash test data.

A low speed ΔV of 10 mph and a high speed ΔV of 20 mph were selected for most of the tests. (One high speed test was conducted at a

ΔV of 25 mph.) The struck car was stationary in each case and the impacting speed of the striking vehicle (NHTSA's moving barrier with a rigid front) varied based upon its weight and that of the struck car. This impact velocity was calculated as follows:

$$v_B = \frac{m_T}{m_B}(\Delta V)$$

This formula assumed a plastic collision where m_B was the mass of the moving barrier, m_T was the combined mass of the barrier and struck car, and v_B was the velocity of the barrier, or the impact velocity.

It was felt that the low speed test would not significantly damage the opposite side of the struck car. It was therefore possible to perform two collisions on each vehicle. First, the left side was impacted at the lower speed, and then the car was turned around and struck on the right side at the higher speed. This produced a low/high speed pair of data points for each car tested as well as conserved project funds.

It was also necessary to define the impact location on each car. Nine occupant compartment impacts and two impacts into the front axle were conducted. For the occupant compartment impacts, it was desired to avoid other structures such as the axles. It was also desired to center the impact as near to the struck vehicle's longitudinal center of gravity as possible, to minimize rotation. In most cases, centering the barrier on the vehicle's c.g. resulted in contact into the front wheelwell. Therefore, the impact location was selected for each car such that the leading edge of the barrier face was slightly rearward of the front wheelwell. The result of this was that the center of the impact area was slightly rearward of the vehicle's c.g. for each case. The non-compartment pair of tests was done with the same vehicle model as one of the pairs of compartment impacts. This allowed a comparison between the two types of impacts. Figures 3.1 and 3.2 show the pre-test set-up for one of the LTD tests.

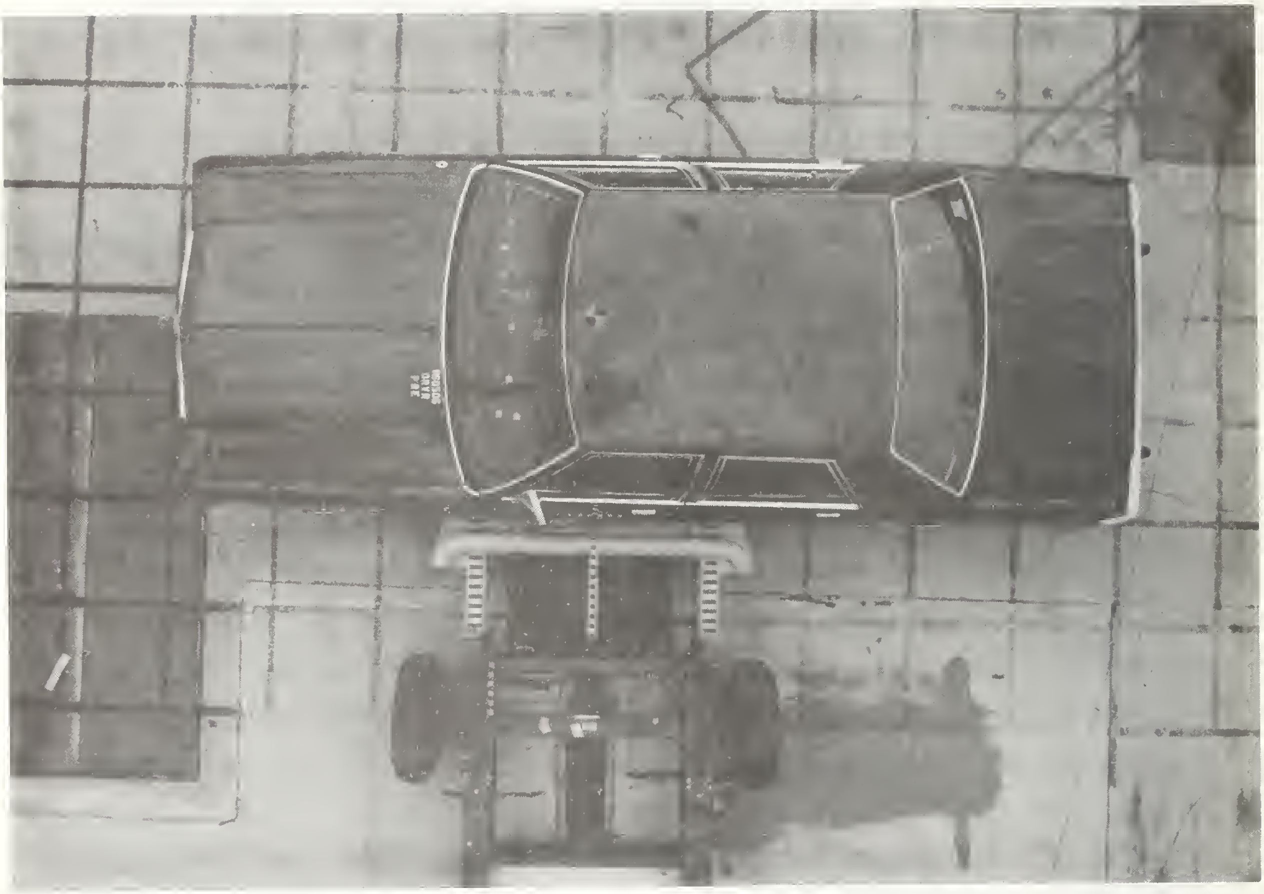


FIGURE 3.1 -- LTD Pre-Test Overhead View

FIGURE 3.2 -- LTD Pre-Test Side View

The NHTSA moving barrier is capable of performing impacts at different angles as well as being "crabbed" to simulate two-car moving collisions. It was judged that a 90° impact without crabbing would allow the most straight forward derivation of stiffnesses. Crabbing is probably more representative of real world collisons but the analysis is complicated by vehicle shearing and rotation.

As mentioned, the striking vehicle for each test was the NHTSA moving barrier with a rigid front. Typically, this device is used in conjunction with a deformable honeycomb front to simulate the front end stiffness of the impacting vehicle. To determine the stiffness characteristics, however, the energy used in deforming the struck vehicle must be calculated. If deformation also occurs in the striking vehicle, it is difficult, if not impossible, to determine how much of the energy caused the struck vehicle deformation. Therefore, in order to make it possible to accurately determine the amount of energy expended in deforming the struck vehicle, a rigid front was constructed for the moving barrier.

This rigid front was built to be approximately representative of the geometry of cars on the road. The frontal geometry of a number of vehicles was measured and sales weighted averages computed. These averages are listed below. Since they are based upon a relatively small sample, the numbers are not recommended for other applications. The weight of the barrier with this rigid front installed was 3237 lb (see Figure 3.3).

[NOTE: It is emphasized that this rigid barrier has no connection with the NHTSA Moving Deformable Barrier (MDB). This barrier is designed to be approximately representative of the geometry of passenger cars. The MDB is designed to represent both the geometry and stiffness of passenger cars and light trucks and vans.]

frontal width - 62.5"
hood height - 30"
bumper width - 6"
bumper height - 17" (center)

FIGURE 3.3 -- Rigid Front for NHTSA Moving Barrier

3.2 Crush Measurement Procedures

Data were collected from each test, including ten channels of acceleration. Three accelerometers were located at the struck vehicle's c.g. and two at the rear deck. Three were also located at the barrier c.g., with two at the rear cross-member. The most significant data collected, though, were the post-test crush measurements. It was necessary, therefore, to find a uniform method of obtaining these measurements. Mr. Robert Romberg, NHTSA's NASS Training Coordinator, Traffic Safety Institute, visited the VRTC to demonstrate the procedure used by accident investigation teams in the field as well as to take the damage measurements from the vehicles tested in this study. This method is described in the following text.

First, the length of damage, L, was determined. The rearward and forward most points of damage, including both direct and induced damage, were located. The distance between these two points was recorded as 'L' and a string line was attached between the points. This length was then divided into five equal parts which were marked off along the string. These marks represented the six crush measurement locations, C1 to C6, with C1 being the rearward most point of damage and C6 being the forward most point of damage.

Using a plumb bob and a tape measure, the horizontal distance from the string line to the sheet metal, at the height of maximum crush, was measured and recorded for each of locations C1 through C6. Using the undamaged side of the vehicle, the distance from the string line to the undamaged sheet metal at these same locations was measured and recorded as 'freespace'. This distance was then subtracted from the maximum intrusion measured previously and recorded as 'net maximum crush'. If there was no major structural failure, such as the B-pillar tearing away at the sill, and there was no bowing of the car, these adjusted measurements were used as the final values for C1 through C6.

If there was major structural damage, the sill crush was also used. As with the maximum crush, the horizontal distance from the string line to the sill was measured at each of the six locations. After obtaining the 'sill freespace' in the same manner as above, this value was subtracted from each of the previously measured distances. This 'net sill crush' was then averaged with the 'net maximum crush' described previously. If there was no bowing of the car, these 'net average crush' measurements were used as the final values for C1 through C6.

The bowing factor was determined in the following manner. Using the roof as a reference, a line was made through the original longitudinal centerline of the car. If neither the front nor the rear of the car had been displaced more than four inches, the bowing factor was zero. Otherwise, a second string line was attached to the side of the car at the most protruding structures in both the front and rear of the car. The horizontal distance from this string to the first string was measured and recorded at the C1 and C6 locations. The average of these two values was the bowing factor. Final values for C1 through C6 were then found by adding this bowing factor to each of the 'net maximum' or 'net average' crush values found as described previously.

The last damage measurement was the center of damage (c.o.d.) offset, D. The c.o.d. was located at a distance of L/2 from both the C1 and C6 locations along the first string line. The distance from the c.o.d. to the vehicle's c.g. was recorded as D. This value was positive if the c.o.d. was forward of the c.g. and negative if it was rearward of the c.g. It is important to note that accident investigation teams in the field estimate the c.g. of a car to be the center of the wheelbase. Their D measurements are therefore the distance from the c.o.d. to the center of the wheelbase. Since the actual c.g. of the cars were known in this study, all reported D measurements are relative to the actual c.g.

Although this procedure appeared to be a very straight forward approach to obtaining the desired damage measurements, there was a degree of subjectivity in it. For instance, defining the area of damage, the length of which was defined as 'L', was not always clear cut. Frequently, very minor induced damage occurred outside of the area that would intuitively be included in the damage region. This made it necessary to subjectively decide whether or not to extend the damage region to this point. Due to this type of occurrence as well as the location of the damage relative to wheelwells and vehicle discontinuities, it was often very difficult to determine what to include in this region. This measurement would therefore be expected to vary somewhat, depending on the person taking it. This would then affect the location of the six crush measurements, to some extent their magnitudes, and the offset value, D.

As mentioned previously, it was also necessary to determine if major structural failure had occurred. While this would certainly be very obvious in some cases, it would not always be expected to be clear cut. Since the maximum and sill crush measurements were greatly different and were averaged if failure occurred, the final crush values were very dependent on the outcome of this decision. Mr. Romberg suggested that one possible alternative to this potential source of variability would be to change the field procedure to always average the maximum and sill crush measurements. This would also give a better overall description of the extent of the damage than just the maximum crush measurement. Although sill crush measurements were taken for all the tests done in this study, they were not used unless it was determined that major structural failure occurred (i.e., the existing field procedure was followed).

4.0 RESULTS

4.1 Compartment Tests With 10 and 20 mph Delta-V's

A total of eleven channels of data were recorded for each test. These included the ten channels of acceleration outlined in section 3.2 and a yaw rate channel. These results can be found in the crash test report issued for each vehicle. The main outcome of these tests were the post-test damage measurements. Table 4.1 lists the various conditions and parameters for each of the eight compartment impact tests which were done at a ΔV of either 10 or 20 mph. Table 4.2 lists the

TABLE 4.1 -- Test Conditions & Parameters

Compartment Tests @ 10 & 20 mph ΔV's

Vehicle	Test Number	Impact Type	Vehicle Weight (lb)	MRB Speed (mph)	ΔV (mph)
Ford	8605161	comp	1985	16.1	10.0
Escort	8605162	comp	1985	32.2	20.0
Mitsubishi	8605231	comp	2161	16.7	10.0
Tredia	8605232	comp	2161	33.5	19.9
Chevrolet	8603261	comp	2784	18.5	10.0
Citation	861015	comp	2420	35.2	20.0
Ford	8605061	comp	3554	20.9	10.0
LTD	8605062	comp	3554	42.1	20.1

TABLE 4.2 -- Damage Measurements

Compartment Tests @ 10 & 20 mph ΔV's

Vehicle	Damage Measurements (inches)							
	L	C1	C2	C3	C4	C5	C6	D
Ford	75.0	0.0	5.3	5.2	5.6	5.2	0.0	-13.1
Escort	102.0	3.2	19.0	19.2	19.7	18.6	3.2	-14.6
Mitsubishi	80.0	0.0	4.2	4.2	5.0	5.5	0.0	-14.8
Tredia	99.5	0.7	11.9	16.0	14.4	13.3	0.7	-12.8
Chevrolet	78.0	0.0	9.1	8.6	8.7	8.3	0.0	-11.1
Citation	100.0	1.8	17.5	17.0	17.5	10.0	1.8	-9.5
Ford	85.3	0.0	6.7	6.0	6.2	6.1	0.0	-4.9
LTD	138.5	1.0	8.2	21.1	14.7	12.4	1.0	0.1

damage measurements obtained from each of these tests. Appendix A contains the work sheets for each test that were used to determine these measurements. Appendix B contains force vs. deflection plots for each test.

When damage measurements are used for reconstructions, the CRASH III model assumes the form of crush resistance shown in Figure 4.1. For this formulation, it is necessary to know the values of three stiffness parameters, A, B, and G, which are defined in the figure. There is a set of these parameters for each of the six passenger car side impact categories, which were derived in the study of Reference 1. These categories are divided by wheelbase as follows:

Category	Classification	Wheelbase
1	minicar	80.9 to 94.8
2	subcompact	94.8 to 101.6"
3	compact	101.6 to 110.4"
4	intermediate	110.4 to 117.5"
5	full size	117.5 to 123.2"
6	large	123.2 to 150.0"

To calculate the compartment stiffness parameters from the 10 and 20 mph ΔV crash tests of this study, the data listed in Tables 4.1 and 4.2 were run through the CRUSH algorithm (2). From this, three values were calculated, E, α, and β. E is the energy absorbed in the collision (in·lbs), α is the plan view area of damage assuming a uniform vertical damage profile (in^2), and β is the first moment of this damage area about the line defining the original (undeformed) surface (in^3). A copy of the CRUSH run for each test can be found in Appendix C.

Once these CRUSH values were found for all the cars, they were entered into the NLIN routine from the Statistical Analysis System (SAS) package. Also entered was the damage length, L, for each test. The NLIN routine will find an A and B, and thus G, for any number of sets of CRUSH values, greater than one. These are found such that the following energy equation is fit, to meet a given convergence criterion, for each individual test:

$$E = A\alpha + B\beta + GL$$

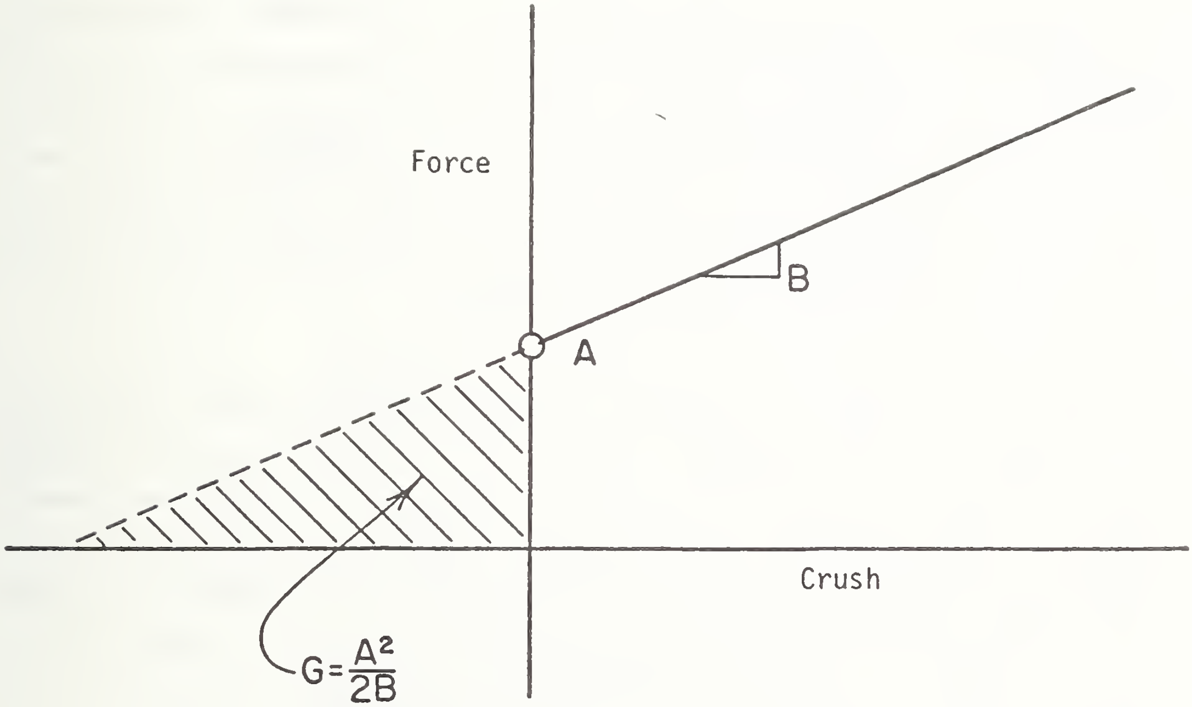


FIGURE 4.1 -- CRASH III Formulation for Crush Resistance

Stiffness parameters were calculated for each individual vehicle using the low and high speed test results, as well as for a combination of the vehicles. The vehicle models tested were chosen such that each was in a separate wheelbase category (1-Escort, 2-Tredia, 3-Citation, 4-LTD). Table 4.3 lists the parameters found for the individual cars (wheelbase categories), as well as for the combination. Table 4.4 lists the side stiffness parameters that are currently used in the CRASH III model.

Ultimately, the effectiveness of a set of stiffness parameters is measured by its ability to predict the velocity change of a collision when used in the CRASH III computer model. The parameter sets in Table 4.3 were entered into the program and used to reconstruct these same collisions. Ideally, these reconstructions would have been done with tests other than those used to calculate the parameters. This was not done since data of this type were very limited.

Table 4.5 lists the results of these reconstructions. Note that each crash was reconstructed using its individual set of stiffness parameters as well as the set found by combining all eight compartment impacts. As expected, the individual parameters did a good job of predicting velocity changes, with an average error of 2.9%. Even though this is a small error, closer agreement was expected since these collisions were used to calculate the stiffness parameters. The lack of near perfect reconstructions may be an indication of a deficiency in the model's energy formulation presented previously. As expected, the combined stiffness parameters produced less accurate reconstructions, with an average error of 16.0%. This observation that individual stiffness parameters produce better reconstructions than did a combined average cannot be extended to the general case where the collisions being reconstructed are not those that were used to derive the stiffness parameters. In fact, it was noted in Volume I of this final report that combined stiffness parameters worked nearly as well as categorized parameters.

TABLE 4.3 -- New Side Stiffness Parameters

Compartment Tests With 10 & 20 mph ΔV's

Vehicle	Wheelbase Category	Stiffness Parameter		
		A	B	G
Escort	1	141.4	11.09	901.1
Tredia	2	214.9	35.78	645.2
Citation (comp)	3	147.7	47.85	227.8
LTD	4	327.8	45.92	1169.7
combined (8 tests)		236.7	13.75	2037.8

TABLE 4.4 -- Current Side Stiffness Parameters

Wheelbase Category	Stiffness Parameter		
	A	B	G
1	77.2	36.7	81.3
2	140.4	66.7	147.8
3	173.3	57.1	263.2
4	143.0	50.4	202.7
5,6	176.5	47.1	330.8

TABLE 4.5 -- Reconstruction Results

Vehicle	Actual ΔV (mph)	Predicted Velocity Change (mph)					
		individual			combined		
		ΔV	Δ	|%Δ|	ΔV	Δ	|%Δ|
Ford Escort	10.0	9.5	-0.5	5.0%	13.2	3.2	32.0%
	20.0	18.7	-1.3	6.5%	24.0	4.0	20.0%
Mitsubishi Tredia	10.0	9.7	-0.3	3.0%	12.8	2.8	28.0%
	19.9	19.5	-0.4	2.0%	19.5	-0.4	2.0%
Chevrolet Citation (comp)	10.0	9.7	-0.3	3.0%	12.2	2.2	22.0%
	20.0	19.4	-0.6	3.0%	19.0	-1.0	5.0%
Ford LTD	10.0	9.9	-0.1	1.0%	9.9	-0.1	1.0%
	20.1	20.1	0.0	0.0%	16.5	-3.6	17.9%
average		XXXXX		2.9%	XXXXX		16.0%

4.2 Tests With Alternate Impact Conditions

As mentioned previously, three additional crash tests were also done. Two of these were 10 and 20 mph ΔV non-compartment tests on a Chevrolet Citation. In these tests, the moving rigid barrier was positioned such that the impact area on the car would include the front wheel and axle. The third test was a 25 mph ΔV compartment impact also done on a Citation. In this test, the MRB was positioned the same as for the Citation tests listed in Table 4.1. Table 4.6 lists the test conditions and parameters for these three tests while Table 4.7 lists their crush measurements. Table 4.8 lists the stiffness parameters calculated from these results. The results of the 10 mph ΔV Citation test listed in Table 4.2 were used in conjunction with those of the 25 mph ΔV test to find the "alternate speed" parameters.

If the stiffnesses, B values, of these are compared with that for the Citation listed in Table 4.3, it can be seen that the stiffness increased significantly (123%) in the non-compartment impact. In

TABLE 4.6 -- Test Conditions & Parameters

Additional Citation Tests

Vehicle	Test Number	Impact Type	Vehicle Weight (lb)	MRB Speed (mph)	ΔV (mph)
Chevrolet Citation	8604291	n-comp	2602	18.1	10.0
	8604292	n-comp	2602	36.0	20.0
	8603262	comp	2784	46.6	25.0

TABLE 4.7 -- Damage Measurements

Additional Citation Tests

Impact Type	Damage Measurements (inches)							
	L	C1	C2	C3	C4	C5	C6	D
non-compartment	67.0	2.7	6.2	6.2	5.8	3.9	1.4	13.5
	107.5	0.0	5.1	16.0	12.2	6.9	0.0	8.5
ΔV=25 mph	97.0	7.0	10.7	29.9	28.6	28.1	7.0	-14.4

TABLE 4.8 -- Side Stiffness Parameters

Additional Citation Tests

Impact Type	Stiffness Parameter		
	A	B	G
non-compartment	239.1	106.7	267.7
alternate speed	168.6	36.85	385.8

addition, the threshold level for crush, the A value, also increased (62%). These increases were expected since intuitively, the axle area of a vehicle should be considerably more resistant to crush than the compartment side structure.

Similarly, a comparison of the 20 and 25 mph ΔV test results show that the A value increased with increasing speed (14%), while the B value decreased (23%). While these results may suggest that the vehicle stiffness, model formulation, or both are velocity sensitive, the differences were not so large such that a determination of this could be made based on only two data points.

In addition to the variation in stiffness parameters due to the impacted region and impact velocities, that due to the variability in crush measurements was examined. In section 3.2, it was mentioned that the procedure for obtaining these measurements was somewhat subjective. In addition to Mr. Romberg's 'best effort' measurements listed in Table 4.2, he took measurements for each vehicle which bounded what he judged to be a reasonable range for damage area. That is, he took a set of measurements based on both the smallest reasonable and the largest reasonable damage length, L. This was done for the higher speed tests only and in four of the six tests, his 'best effort' measurements were also his 'largest L' measurements. These alternate measurements are listed in Appendix D as well as the stiffness parameters calculated when each set was paired with its corresponding low speed test.

Table 4.9 shows the percentage spread in stiffness parameters due to the variability in taking the crush measurements. The A parameters varied by an average of $\pm 3.6\%$ while the B parameters varied by an average of $\pm 12.2\%$. The non-compartment Citation test showed the greatest variability in both parameters. This was due to the configuration of this particular test. Since the impact was much farther forward of the vehicle's c.g. than the other tests, more vehicle rotation occurred. This caused the rear wheel of the MRB to hit the rear door of the car, thus damaging it. While Mr. Romberg did not feel that he would include this damage, he thought that some accident investigators may.

TABLE 4.9 -- Measurement Variability on Stiffness Parameters

Vehicle	A	B
Escort	±2.6%	±8.2%
Tredia	±1.1%	±8.0%
Citation (comp)	±4.1%	±6.8%
LTD	±1.8%	±11.2%
Citation (n-comp)	±7.9%	±25.0%
Citation (25 mph)	±3.9%	±14.0%
average	±3.6%	±12.2%

Thus his 'largest L' measurements included this damage, which had a large effect on the crush measurements and resulting stiffness parameters. It is important to note here that these ranges for damage lengths encompass the lengths that expert accident investigators would likely determine. If damage measurements are taken by less experienced personnel, the variability would be expected to increase.

5.0 SUMMARY

The following is a summary of the findings from this study:

1. Based on the results of the 10 and 20 mph ΔV crash tests into the occupant compartments of four vehicles, the following side stiffness parameters were calculated:

Vehicle	wb Category	A	B	G
Escort	1	141.4	11.09	901.1
Tredia	2	214.9	35.78	645.2
Citation	3	147.7	47.85	227.8
LTD	4	327.8	45.92	1169.7

2. When used in the CRASH III model to reconstruct these same tests, the above stiffness parameters had an average error of 2.9%. Although this was good, closer agreement was expected.

3. The results of all eight 10 and 20 mph ΔV occupant compartment crash tests were combined to produce one set of stiffness parameters. These were A = 236.7, B = 13.75, and G = 2037.8. Reconstructions of these tests using this set of parameters in the CRASH III model produced an average error of 16.0%

4. A set of stiffness parameters were found based on 10 and 20 mph ΔV Citation non-compartment crash test results. When compared to that from the compartment tests, a sharp increase in crush resistance was seen. The following table summarizes these results:

Stiffness Parameter	compartment	non-compartment	% increase
A	147.7	239.1	61.9%
B	47.85	106.7	123.0%

5. A set of stiffness parameters were found based on 10 and 25 mph ΔV Citation compartment crash test results. The following table compares these parameters to those from the 10 and 20 mph ΔV Citation compartment crash tests. The differences were not great enough to enable firm conclusions to be made as to the effect of speed varability on stiffness parameters or crush resistance.

Stiffness Parameter	10/20 mph	10/25 mph	% change
A	147.7	168.6	+14.2%
B	47.85	36.85	-23.0%

6. Since the determination of the length of damage, L, is somewhat subjective, some variation in stiffness parameters for the same vehicle was expected due to the resulting variability in crush

measurements. For each vehicle, a range for L that could be expected from expert accident investigators was determined. Crush measurements were taken for each extreme of L and the corresponding stiffness parameters calculated. On average, variations of ±3.6% and ±12.2% were found for the A and B parameters, respectively. Higher variation would be expected if less experienced personnel were to make the crush measurements.

7. The results can be summarized graphically. Figure 5.1 shows the new and current A parameter values, including ranges due to measurement variability. For the most part, the new parameters are higher than the current ones. Figure 5.2 depicts the new and current B parameter values. The new B parameter values, for compartment impacts, are lower than the current ones, increasing with increasing wheelbase and leveling off for the larger cars. This plot also indicates that impact location is an important consideration since the front axle impact resulted in a much higher resistance to crush than any of the occupant compartment impacts.

8. For both the CRUSH and the CRASH III algorithms, the 'D' measurement is defined to be the distance from the center of the damage area to the center of gravity of the vehicle. Accident investigation teams use the center of the wheelbase as an approximation for the center of gravity. This introduces error in the energy calculations of these algorithms. It is felt that a better approximation for the center of gravity of a car could be made in the field, thus reducing this error.

6.0 RECOMMENDATIONS

The results of this study gave indication that smaller cars are less stiff in the compartment area than the CRASH III model values. The parameters derived for the front axle area are much stiffer than those

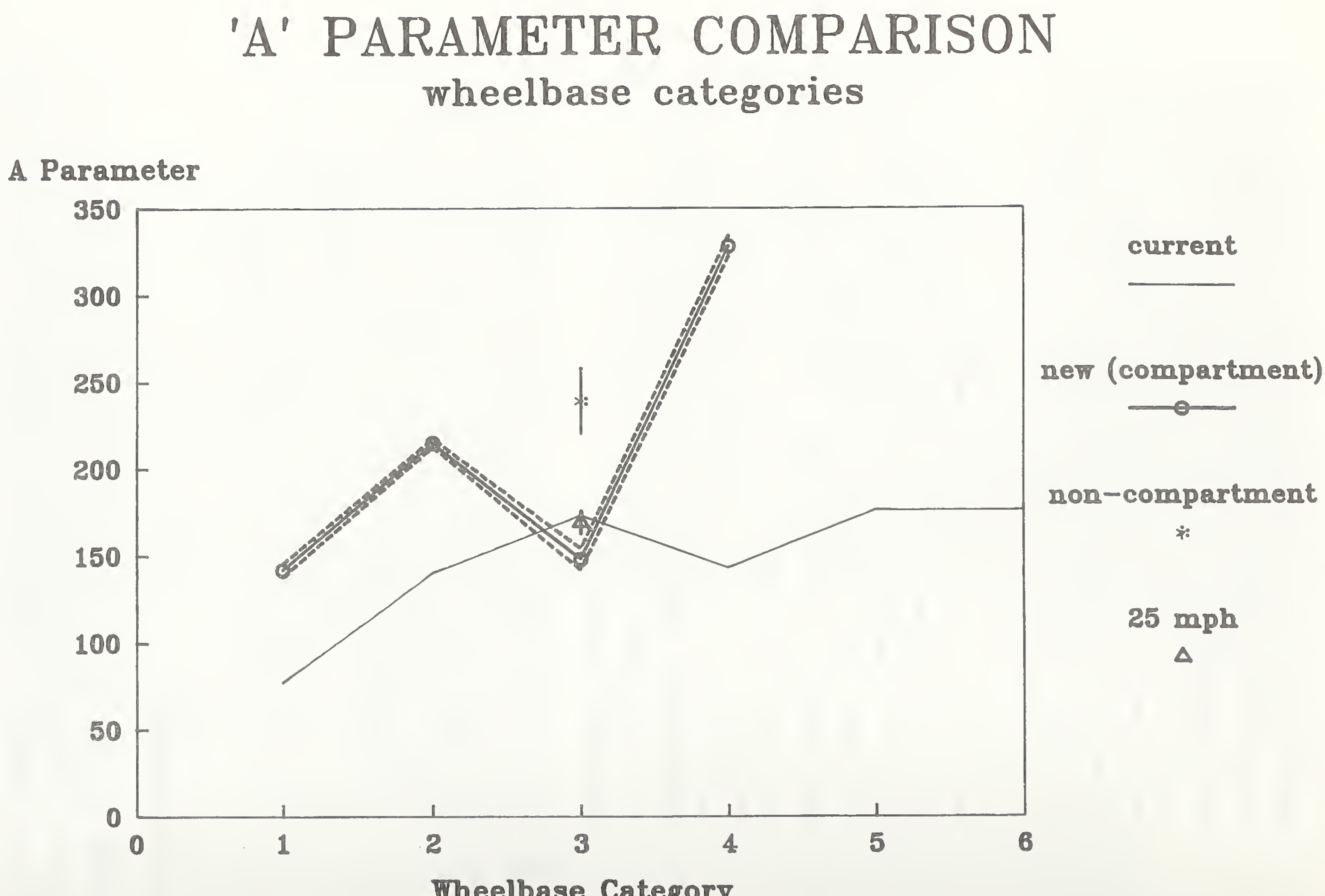


Figure 5.1. 'A' Parameter Comparison

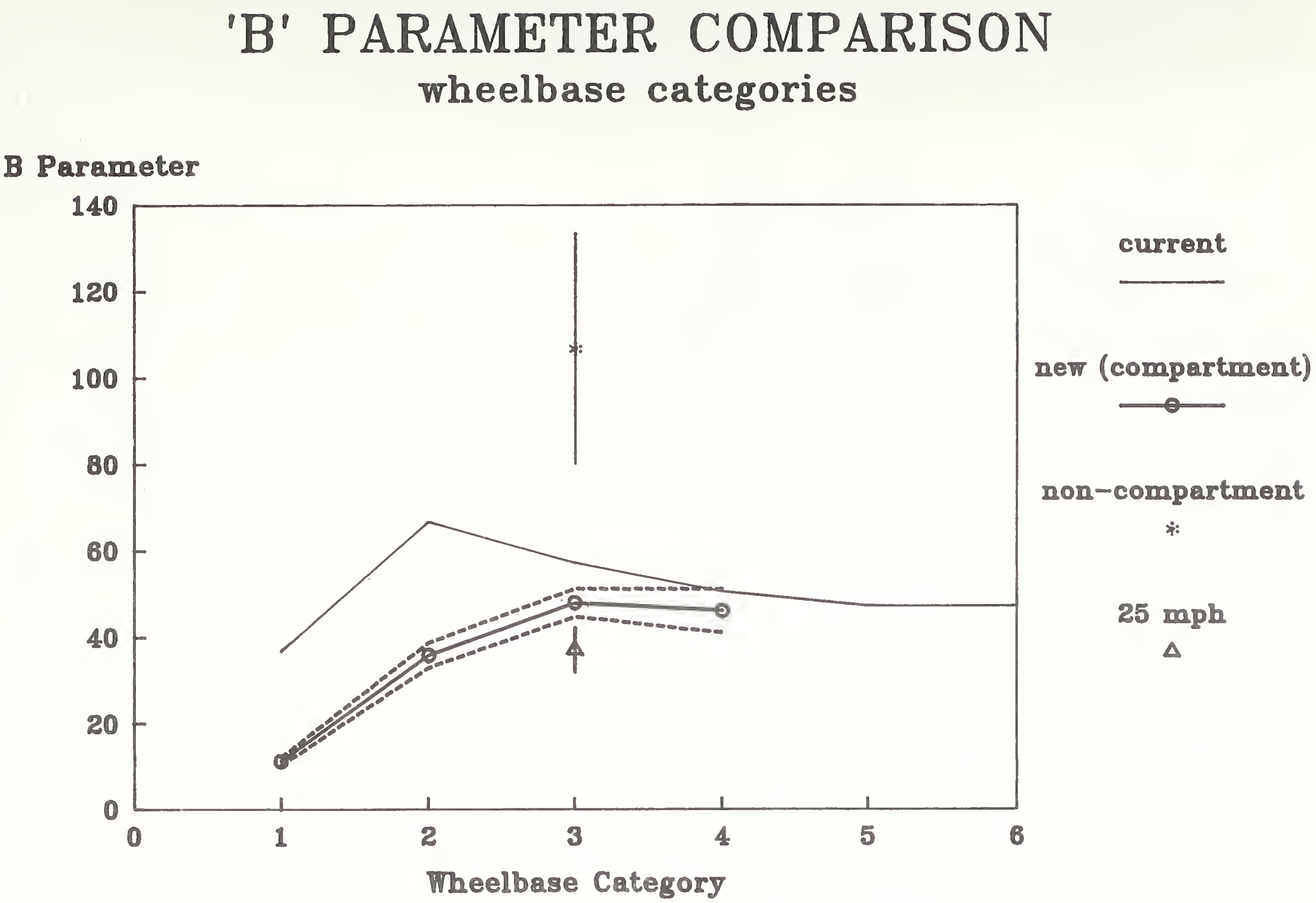


Figure 5.2. 'B' Parameter Comparison

in the model. Since each category was based upon crash test data from one vehicle model, the apparent recommendation would be to do sufficient tests and analysis to verify these differences. However, since a study is being initiated which might lead to a basic reformulation of the stiffness approach used in the CRASH III Model, it is recommended that further study of CRASH III stiffness values be postponed. Based upon the outcome of the reformulation, a decision can be made as to the need for further study of the findings documented in this report.

7.0 REFERENCES

1. M.W. Monk, D.A. Guenther; "Update of CRASH II Computer Model Damage Tables"; NHTSA final report numbers DOT-HS-806-446 (Volume I) and DOT-HS-806-447 (Volume II); March 1983.

2. R.R. McHenry; "Yielding-Barrier Test Data Base-Refinement of Damage Data Tables in the CRASH Program"; NHTSA Interim report number DOT-HS-802-265; February 1977.

APPENDIX A

Damage Measurement Worksheets

NCI

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Escort - 10 mph

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ____	Bowing: B1 ____ X1 ____
Corner shift: A1 ____	B2 ____ X2 ____
A2 ____	Bowing constant
End shift at frame (CDC) (check one) <4 inches X ≥4 inches ____	$\frac{X1 + X2}{2}$ = ____

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	5.3	5.2	5.6	5.2	0	
	Freespace				0	0	0	0	0	0	
	Net Max. Crush			75	0	5.3	5.2	5.6	5.2	0	-13.1
	Sill Crush				-	4.2	4.1	4.5	4.7	-	
	Sill Freespace				-	1.5	1.5	1.5	1.5	-	
	Net Sill Crush				-	2.7	2.6	3.0	3.2	-	

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Tredia - 10 mph

NCI

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ____	Bowing: B1 ____ X1 ____
Corner shift: A1 ____	B2 ____ X2 ____
A2 ____	Bowing constant
End shift at frame (CDC) (check one) <4 inches X; ≥4 inches ____	$\frac{X1 + X2}{2}$ = ____

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts– Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	5.0	5.0	5.8	6.3	0	
	Freespace				-	0.8	0.8	0.8	0.8	-	
	Net Max. Crush			80	0	4.2	4.2	5.0	5.5	0	-14.8
	Sill Crush				-	3.0	3.5	3.7	4.0	-	
	Sill Freespace				-	3.0	3.0	3.0	3.0	-	
	Net Sill Crush				-	0	0.5	0.7	1.0	-	

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

NCI

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Citation (compartment) - 10 mph

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ____	Bowing: B1 ____ X1 ____
Corner shift: A1 ____	B2 ____ X2 ____
A2 ____	Bowing constant
End shift at frame (CDC) (check one) <4 inches X; ≥4 inches ____	$\frac{X1 + X2}{2}$ = ____

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush			78	0	9.1	8.6	8.7	8.3	0	-11.1
	Hood Level Crush				0	5.6	6.5	5.1	4.4	0	

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

LTD - 10 mph

NCI

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ______	Bowing: B1 ______ X1 ______
Corner shift: A1 ______	B2 ______ X2 ______
A2 ______	Bowing constant
End shift at frame (CDC) (check one) <4 inches X; ≥4 inches ______	$\frac{X1 + X2}{2}$ = ______

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts– Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage: Width** (CDC)	Direct Damage: Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	9.0	8.3	8.5	8.4	0	
	Freespace				–	2.3	2.3	2.3	2.3	–	
	Net Max. Crush			85.3	0	6.7	6.0	6.2	6.1	0	-4.9
	Sill Crush				–	5.7	6.8	6.4	6.4	–	
	Sill Freespace				–	4.3	4.3	4.3	4.3	–	
	Net Sill Crush				–	1.4	2.5	2.1	2.1	–	

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Citation (non-compartment) - 10 mph

NCI

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ______	Bowing: B1 ______ X1 ______
Corner shift: A1 ______	B2 ______ X2 ______
A2 ______	Bowing constant
End shift at frame (CDC) (check one) <4 inches X; ≥4 inches ______	$\frac{X1 + X2}{2}$ = ______

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–
Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				3.5	7.0	7.0	6.6	4.8	2.5	
	Freespace				0.8	0.8	0.8	0.8	0.9	1.1	
	Net Max. Crush			67.0	2.7	6.2	6.2	5.8	3.9	1.4	+13.5
	Sill Crush				5.0	5.0	5.6	6.0	-	-	
	Sill Freespace				3.5	3.5	3.5	3.5	-	-	
	Net Sill Crush				1.5	1.5	2.1	2.5	-	-	

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Escort - 20 mph
smallest L

NCI

Complete When Applicable

End Damage	Side Damage
Undeformed end width ____	Bowing: B1 ____ X1 6.7
Corner shift: A1 ____	B2 ____ X2 6.5
A2 ____	Bowing constant
End shift at frame (CDC) (check one) <4 inches ____ ≥4 inches X	$\frac{X1 + X2}{2}$ = 6.6

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–
Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	14.3	14.0	14.2	14.2	0	
	Freespace				0	0.8	0.8	0.8	0.8	0	
A	Net Max. Crush				0	13.5	13.2	13.4	13.4	0	
	Sill Crush				-	9.0	8.8	9.5	10.1	-	
	Sill Freespace				-	2.5	2.5	2.5	2.5	-	
	Net Sill Crush				-	6.5	6.3	7.0	7.6	-	
B	Bowing				6.6	6.6	6.6	6.6	6.6	6.6	
A+B	Net Crush			85	6.6	20.1	19.8	20.0	20.0	6.6	-17.6

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Escort - 20 mph
largest L (best effort)

NCI

Complete When Applicable	
End Damage	Side Damage
Undeformed end width ____ Corner shift: A1 ____ A2 ____ End shift at frame (CDC) (check one) <4 inches ____ ≥4 inches X	Bowing: B1 ____ X1 4.2 B2 ____ X2 2.2 Bowing constant $\frac{X1 + X2}{2}$ = 3.2

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	16.8	17.0	17.5	16.4	0	
	Freespace				0	1.0	1.0	1.0	1.0	0	
A	Net Max. Crush				0	15.8	16.0	16.5	15.4	0	
	Sill Crush				-	11.5	12.1	13.0	12.8	-	
	Sill Freespace				-	2.5	2.5	2.5	2.5	-	
	Net Sill Crush				-	9.0	9.6	10.5	10.3	-	
B	Bowing				3.2	3.2	3.2	3.2	3.2	3.2	
A+B	Net Crush			102.0	3.2	19.0	19.2	19.7	18.6	3.2	-14.6

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Tredia - 20 mph
smallest L

NCI

Complete When Applicable	
End Damage	Side Damage
Undeformed end width ____	Bowing: B1 ____ X1 1.7
Corner shift: A1 ____	B2 ____ X2 6.5
A2 ____	Bowing constant
End shift at frame (CDC) (check one) <4 inches ____ ≥4 inches X	$\frac{X1 + X2}{2}$ = 4.1

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts– Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	20.8	18.3	16.9	16.0	0	
	Freespace				0	0.8	0.8	0.8	0.8	0	
A	Net Max. Crush				0	20.0	17.5	16.1	15.2	0	
	Sill Crush				-	5.5	10.6	10.0	8.6	-	
	Sill Freespace				-	5.0	5.0	5.0	5.0	-	
B	Net Sill Crush				-	0.5	5.6	5.0	3.6	-	
C	Bowing				4.1	4.1	4.1	4.1	4.1	4.1	
$\frac{A+B}{2}+C$	Net Crush			81	4.1	14.4	15.7	14.7	13.5	4.1	-15.8

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Tredia - 20 mph
largest L (best effort)

NCI

Complete When Applicable

End Damage	Side Damage
Undeformed end width ____	Bowing: B1 ____ X1 0
Corner shift: A1 ____	B2 ____ X2 1.4
A2 ____	Bowing constant
End shift at frame (CDC) (check one) <4 inches ____ ≥4 inches X	$\frac{X1 + X2}{2}$ = 0.7

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–
Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	23.1	20.9	20.7	19.0	0	
	Freespace				0	0.8	0.8	0.8	0.8	0	
A	Net Max. Crush				0	22.3	20.1	19.9	18.2	0	
	Sill Crush				-	4.0	15.5	12.5	12.0	-	
	Sill Freespace				-	5.0	5.0	5.0	5.0	-	
B	Net Sill Crush				-	0	10.5	7.5	7.0	-	
C	Bowing				0.7	0.7	0.7	0.7	0.7	0.7	
$\frac{A+B}{2}+C$	Net Crush			99.5	0.7	11.9	16.0	14.4	13.3	0.7	-12.8

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Citation (compartment) - 20 mph
smallest L

NCI

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ____	Bowing: B1 ____ X1 2.4
Corner shift: A1 ____	B2 ____ X2 8.0
A2 ____	Bowing constant
End shift at frame (CDC) (check one) <4 inches ____ ≥4 inches X	$\frac{X1 + X2}{2}$ = 5.2

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–
Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	15.2	13.7	12.5	12.0	0	
	Freespace				0	0.8	0.8	0.8	0.8	0	
A	Net Max. Crush				0	14.4	12.9	11.7	11.8	0	
	Sill Crush				–	9.6	12.0	9.6	8.0	–	
	Sill Freespace				–	5.5	5.5	5.5	5.5	–	
	Net Sill Crush				–	4.1	6.5	4.1	2.5	–	
B	Bowing				5.2	5.2	5.2	5.2	5.2	5.2	
A+B	Net Crush			81.5	5.2	19.6	18.1	16.9	17.0	5.2	-15.0

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Citation (compartment) - 20 mph

largest L (best effort)

NCI

Complete When Applicable

End Damage	Side Damage
Undeformed end width ______	Bowing: B1 ______ X1 2.0
Corner shift: A1 ______	B2 ______ X2 1.6
A2 ______	Bowing constant
End shift at frame (CDC) (check one) <4 inches ______ ≥4 inches X	$\frac{X1 + X2}{2}$ = 1.8

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–
Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	16.5	16.0	16.5	9.0	0	
	Freespace				0	0.8	0.8	0.8	0.8	0	
A	Net Max. Crush				0	15.7	15.2	15.7	8.2	0	
	Sill Crush				–	13.0	13.7	12.6	–	–	
	Sill Freespace				–	5.5	5.5	5.5	–	–	
	Net Sill Crush				–	7.5	8.2	7.1	–	–	
B	Bowing				1.8	1.8	1.8	1.8	1.8	1.8	
A+B	Net Crush			100.0	1.8	17.5	17.0	17.5	10.0	1.8	-9.5

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

LTD - 20 mph
smallest L

NCI

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ____	Bowing: B1 ____ X1 4.7
Corner shift: A1 ____	B2 ____ X2 3.5
A2 ____	Bowing constant
End shift at frame (CDC) (check one) <4 inches ____ ≥4 inches X	$\frac{X1 + X2}{2}$ = 4.1

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts– Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	25.4	23.3	22.6	14.8	0	
	Freespace				0	2.3	2.3	2.3	1.0	0	
A	Net Max. Crush				0	23.1	21.0	20.3	13.8	0	
	Sill Crush				-	10.7	20.0	9.3	-	-	
	Sill Freespace				-	4.3	8.3	8.3	-	-	
B	Net Sill Crush				-	6.4	11.7	1.0	-	-	
C	Bowing				4.1	4.1	4.1	4.1	4.1	4.1	
$\frac{A+B}{2}+C$	Net Crush			111.5	4.1	18.9	20.5	14.8	17.9	4.1	-1.2

*Identity the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

LTD - 20 mph
largest L (best effort)

NCI

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ______	Bowing: B1 ______ X1 2.0
Corner shift: A1 ______	B2 ______ X2 0
A2 ______	Bowing constant
End shift at frame (CDC) (check one) <4 inches ______ ≥4 inches X	$\frac{X1 + X2}{2}$ = 1.0

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–
Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	12.0	26.7	25.7	11.4	0	
	Freespace				0	2.3	2.3	2.3	0	0	
A	Net Max. Crush				0	9.7	24.4	23.4	11.4	0	
	Sill Crush				-	9.0	24.0	12.2	-	-	
	Sill Freespace				-	4.3	8.3	8.3	-	-	
B	Net Sill Crush				-	4.7	15.7	3.9	-	-	
C	Bowing				1.0	1.0	1.0	1.0	1.0	1.0	
$\frac{A+B}{2}+C$	Net Crush			138.5	1.0	8.2	21.1	14.7	12.4	1.0	+0.1

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Citation (non-compartment) - 20 mph

smallest L (best effort)

NCI

Complete When Applicable	
End Damage	Side Damage
Undeformed end width ______ Corner shift: A1 ______ A2 ______ End shift at frame (CDC) (check one) <4 inches __X__ ≥4 inches ______	Bowing: B1 ______ X1 ______ B2 ______ X2 ______ Bowing constant $\frac{X1 + X2}{2}$ = ______

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts-
Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage		Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
		Width** (CDC)	Max*** Crush								
	Maximum Crush				0	5.9	16.8	13.0	6.9	0	
	Freespace				0.8	0.8	0.8	0.8	0	0	
	Net Max. Crush			107.5	0	5.1	16.0	12.2	6.9	0	+8.5
	Sill Crush				3.5	6.0	10.9	9.0	-	-	
	Sill Freespace				3.5	3.5	3.5	3.5	-	-	
	Net Sill Crush				0	2.5	7.4	5.5	-	-	

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

NCI

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Citation (non-compartment) - 20 mph

largest L

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ______	Bowing: B1 ______ X1 ______
Corner shift: A1 ______	B2 ______ X2 ______
A2 ______	Bowing constant
End shift at frame (CDC) (check one) <4 inches __X__ ≥4 inches ______	$\frac{X1 + X2}{2}$ = ______

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts—Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	5.7	20.0	15.8	8.0	0	
	Freespace				3.4	3.0	2.4	2.0	0.6	0	
	Net Max. Crush			120.0	0	2.7	17.6	13.8	7.4	0	+5.3
	Sill Crush				-	7.2	11.6	11.3	-	-	
	Sill Freespace				-	5.7	5.1	4.7	-	-	
	Net Sill Crush				-	1.5	6.5	6.6	-	-	

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Citation (compartment) - 25 mph
best effort

NCI

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ______	Bowing: B1 ______ X1 2.5
Corner shift: A1 ______	B2 ______ X2 11.5
A2 ______	Bowing constant
End shift at frame (CDC) (check one) <4 inches ______ ≥4 inches X	$\frac{X1 + X2}{2}$ = 7.0

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–
Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	4.5	35.8	33.0	30.0	0	
	Freespace				–	0.8	0.8	0.8	0.8	–	
A	Net Max. Crush				0	3.7	35.0	29.2	29.2	0	
	Sill Crush				–	–	14.2	16.5	16.5	–	
	Sill Freespace				–	–	3.5	3.5	3.5	–	
B	Net Sill Crush				–	–	10.7	13.0	13.0	–	
C	Bowing				7.0	7.0	7.0	7.0	7.0	7.0	
$\frac{A+B}{2}+C$	Net Crush			97.0	7.0	10.7	29.9	28.1	28.1	7.0	-14.4

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Citation (compartment) - 25 mph
smallest L

NCI

Complete When Applicable	
End Damage	**Side Damage**
Undeformed end width ____	Bowing: B1 ____ X1 2.5
Corner shift: A1 ____	B2 ____ X2 16.0
A2 ____	Bowing constant
End shift at frame (CDC) (check one) <4 inches ____ ≥4 inches X	$\frac{X1 + X2}{2}$ = 9.3

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts– Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	3.5	33.7	31.0	26.6	0	
	Freespace				–	0.8	0.8	0.8	0.8	–	
A	Net Max. Crush				0	2.7	32.9	30.2	25.8	0	
	Sill Crush				–	–	10.6	15.6	17.0	–	
	Sill Freespace				–	–	6.0	8.0	8.0	–	
B	Net Sill Crush				–	–	4.6	7.6	9.0	–	
C	Bowing				9.3	9.3	9.3	9.3	9.3	9.3	
$\frac{A+B}{2}+C$	Net Crush			91.5	9.3	12.0	28.1	28.2	26.7	9.3	-21.9

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

Note: Use as many lines/columns as necessary to describe each damage profile.

PSU/Case Number _ _ _ _ _
Vehicle Number _ _

National Accident Sampling System — Continuous Sampling Subsystem: Vehicle Data

FIELD MEASUREMENTS

Citation (compartment) - 25 mph
largest L

NCI

Complete When Applicable	
End Damage	Side Damage
Undeformed end width ____	Bowing: B1 ____ X1 1.7
Corner shift: A1 ____	B2 ____ X2 2.3
A2 ____	Bowing constant
End shift at frame (CDC) (check one) <4 inches ____ ≥4 inches X	$\frac{X1 + X2}{2}$ = 2.0

Note: Measure C1 to C6 from Driver to Passenger side in Front or Rear impacts–
Rear to Front in Side impacts.

Specific Impact Number	Plane* of C-Measurements	Direct Damage Width** (CDC)	Direct Damage Max*** Crush	Field L**	C_1	C_2	C_3	C_4	C_5	C_6	±D
	Maximum Crush				0	39.0	39.3	37.7	11.0	0	
	Freespace				–	0.8	0.8	0.8	0.8	–	
A	Net Max. Crush				0	38.2	38.5	36.9	10.2	0	
	Sill Crush				–	8.9	23.3	28.4	–	–	
	Sill Freespace				–	6.0	8.0	8.0	–	–	
B	Net Sill Crush				–	2.9	15.3	20.4	–	–	
C	Bowing				2.0	2.0	2.0	2.0	2.0	2.0	
$\frac{A+B}{2}+C$	Net Crush			116.5	2.0	22.6	28.9	30.7	12.2	2.0	-9.9

*Identify the plane at which the C-measurements are taken (e.g., at bumper, above bumper, at sill, above sill, at beltline, etc.) or label adjustments (e.g., free space).

Free space value is defined as the distance between the baseline and the original body contour taken at the individual C locations. This may include the following: bumper lead, bumper taper, side protrusion, side taper, etc. Record the value for each C-measurement and maximum crush.

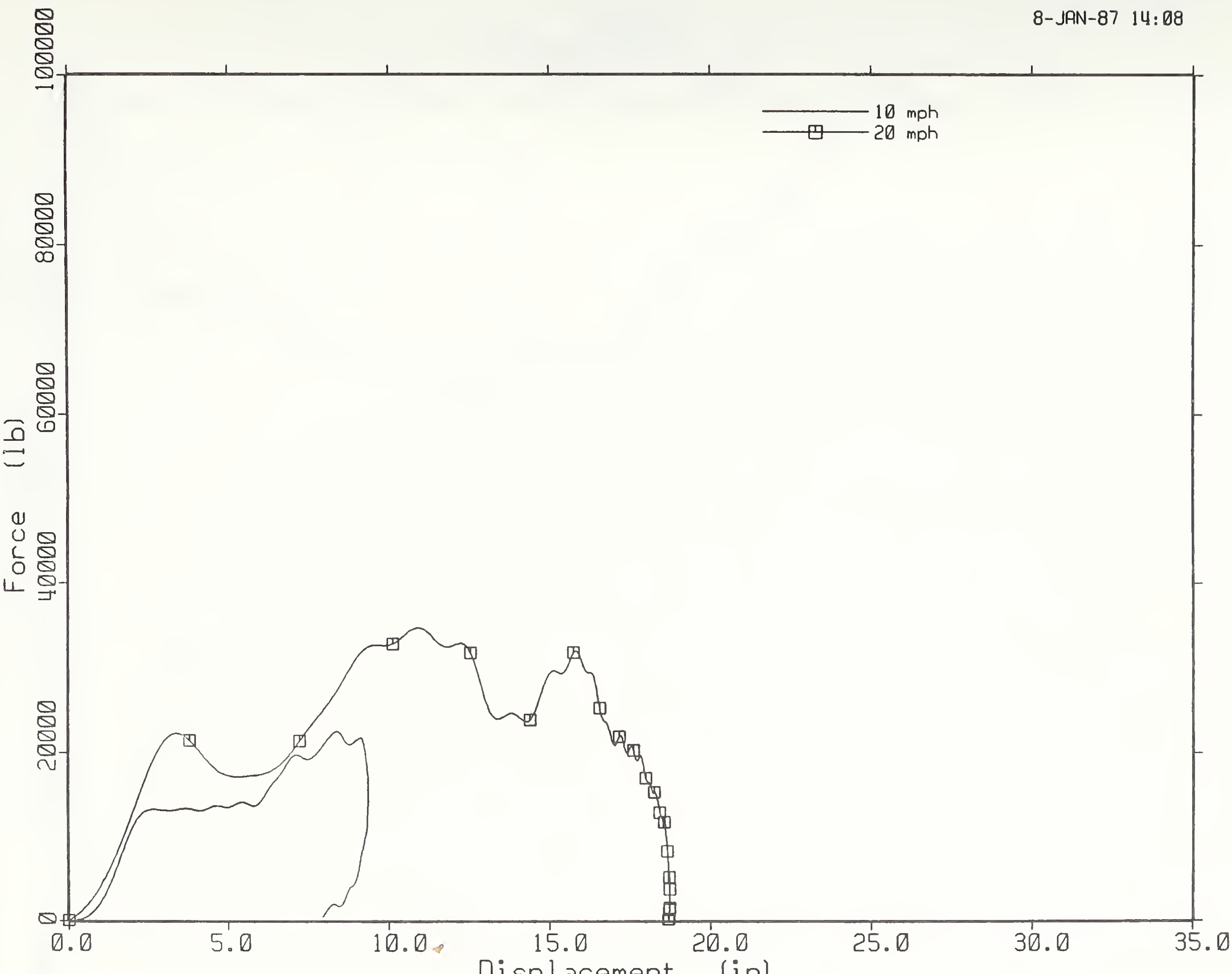
**Measure and document on the vehicle diagram the beginning or end of the direct damage width and field L (e.g., side damage with respect to undamaged axle.)

***Measure and document on the vehicle diagram the location of the maximum crush.

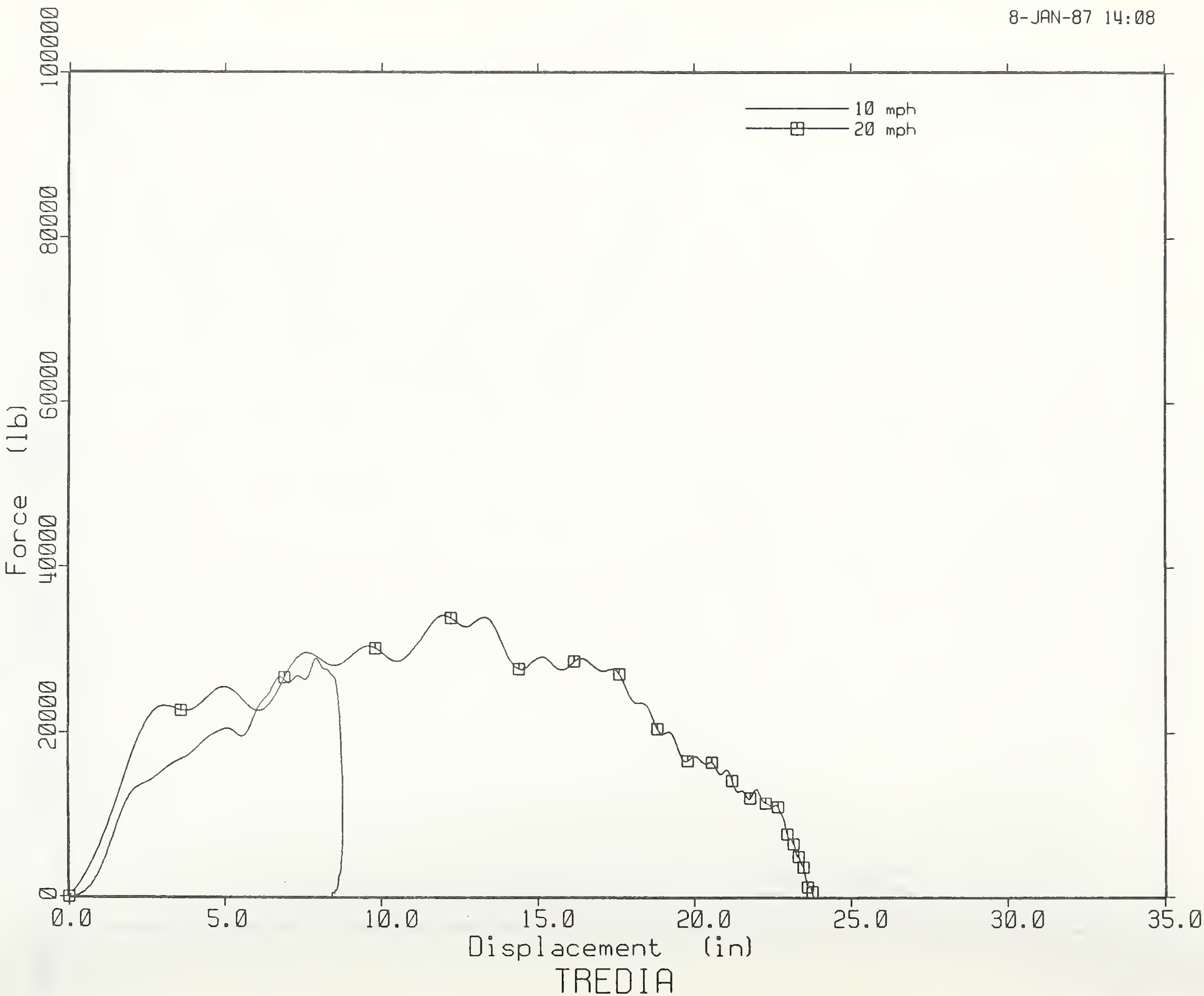
Note: Use as many lines/columns as necessary to describe each damage profile.

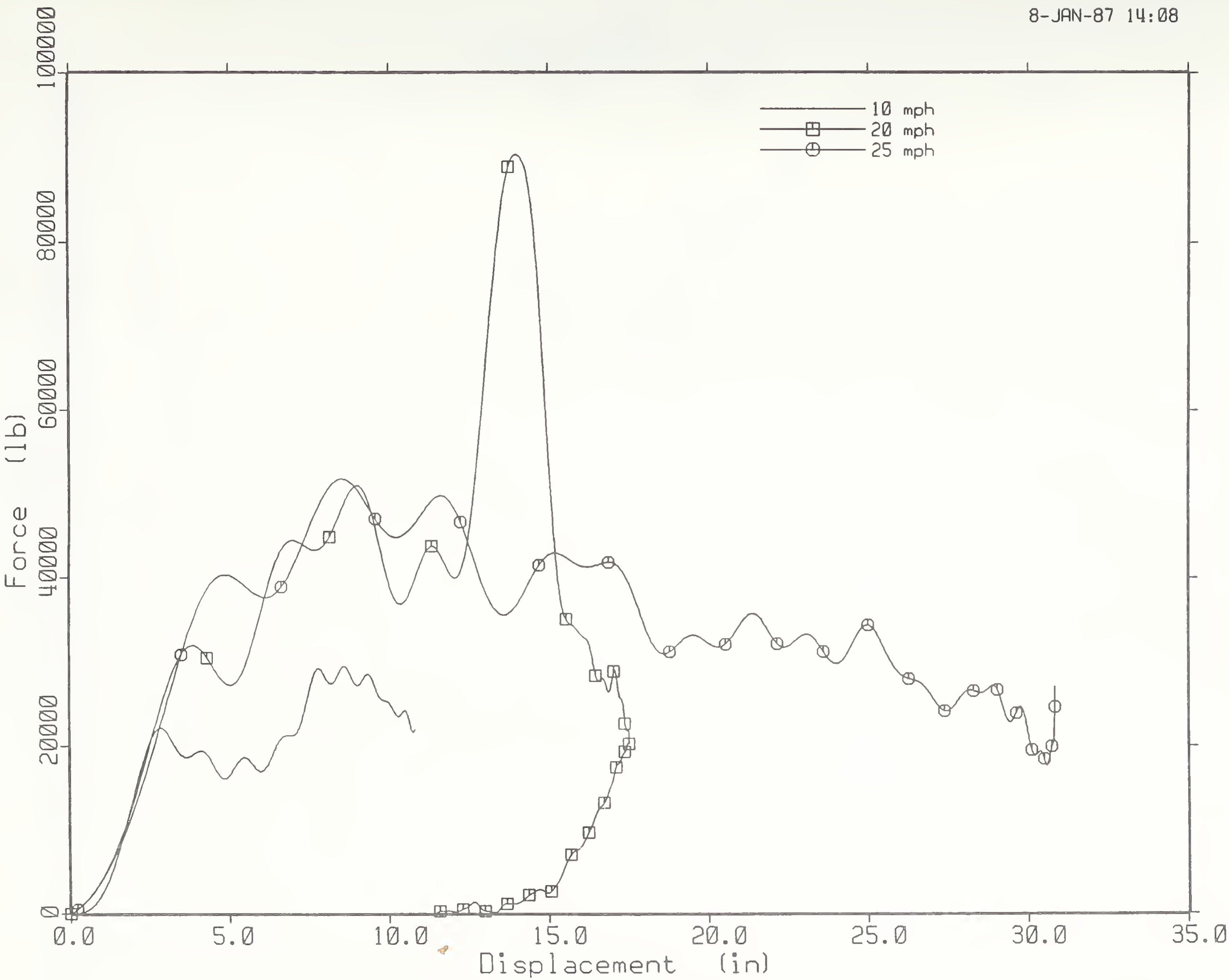
APPENDIX B

Side Impact Force vs. Deflection Plots

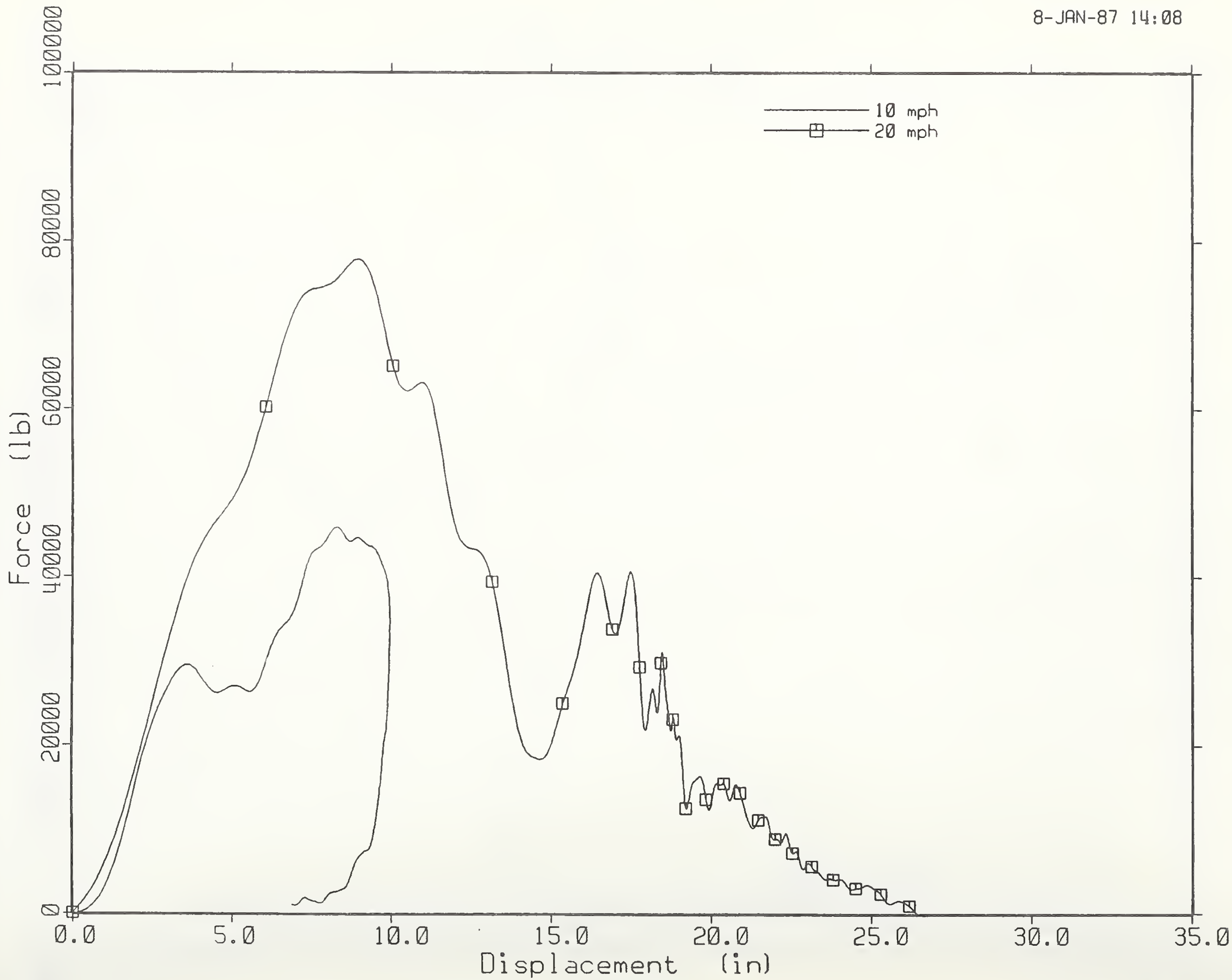

8-JAN-87 14:08
10 mph
20 mph
Force (lb)
100000
80000
60000
40000
20000
0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Displacement (in)

ESCORT

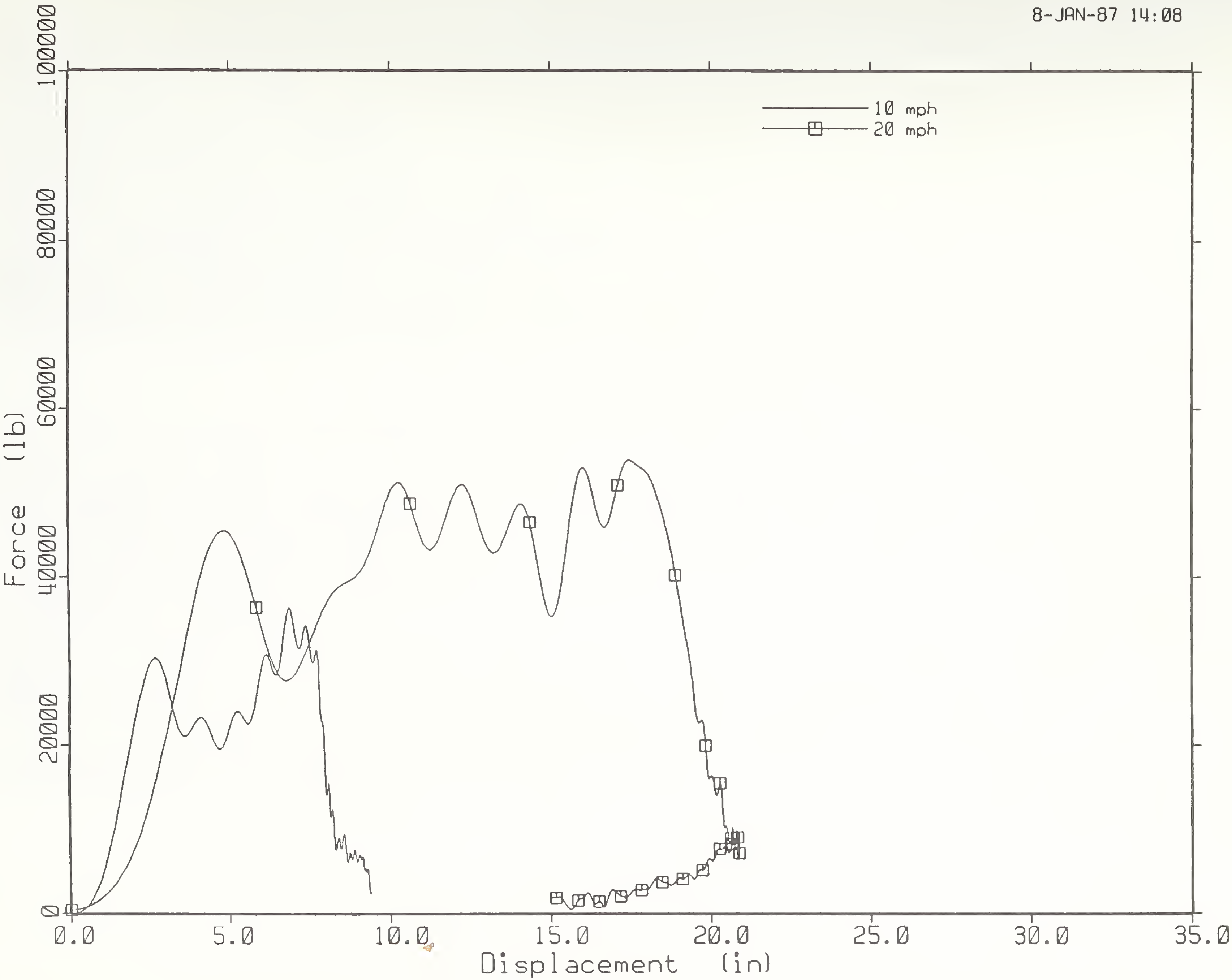

8-JAN-87 14:08
10 mph
20 mph
Force (lb)
0
20000
40000
60000
80000
100000
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Displacement (in)
TREDIA



CITATION (compartment)


8-JAN-87 14:08
10 mph
20 mph
Force (lb)
0
20000
40000
60000
80000
100000
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Displacement (in)

LTD



CITATION (non-compartment)

APPENDIX C

Side Impact CRUSH Runs

```
Title: ESCORT - LOW SPEED - D=COG
Size category vehicle no. 1: 1
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 1985
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 09LDEW2
Vehicle damage indice no. 2: 12FDEW2\2\1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 16.1
Direction of principal force for vehicle no. 1: 270
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 75
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 0,5.3,5.2,5.6,5.2,0
Damage midpoint offset for vehicle no. 1: -13.1
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

ESCORT - LOW SPEED - D=COG
VEHICLE TYPES :      1     7
VEHICLE WEIGHTS:     1985.00   3237.00
VEHICLE DAMAGE INDICES: 09LDEW2    12FDEW1
COLLISION SPEEDS:        0.00    283.36
A(2),B(2),G(2):        0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:      270.00     360.00
V1 DAMAGE DATA:    75.00          0.00       5.30       5.20       5.60       5.20       0.00      -13.06
V2 DAMAGE DATA:     0.00          0.00       0.00       0.00       0.00       0.00       0.00        0.00
GAM(1:2):       0.92       1.00
ENERGY(2):        0.00
DELV1:    166.85
SUMENG:    121437.43
ENERGY(1):  121437.43
ALPHA1,BETA1:         319.50      782.15

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: TREDIA - LOW SPEED - =DCOG
Size category vehicle no. 1: 2
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2161
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 09LDEW2
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 16.7
Direction of principal force for vehicle no. 1: 270
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 80
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 0,4.2,4.2,5.0,5.5,0
Damage midpoint offset for vehicle no. 1: -14.8
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

TREDIA - LOW SPEED - =DCOG
VEHICLE TYPES :      2    7
VEHICLE WEIGHTS:    2161.00   3237.00
VEHICLE DAMAGE INDICES: 09LDEW2    12FDEW1
COLLISION SPEEDS:        0.00    293.92
A(2),B(2),G(2):        0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:     270.00    360.00
V1 DAMAGE DATA:    80.00          0.00       4.20       4.20       5.00       5.50       0.00     -12.81
V2 DAMAGE DATA:     0.00          0.00       0.00       0.00       0.00       0.00       0.00       0.00
GAM(1:2):        0.95       1.00
ENERGY(2):        0.00
DELV1:   170.57
SUMENG:   140187.16
ENERGY(1):  140187.16
ALPHA1,BETA1:        302.40      659.20

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: CITATION - LOW SPEED - D=COG
Size category vehicle no. 1: 3
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2784
Weight of vehicle no. 2: 3229
Vehicle damage indice no. 1: 09LDEW2
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 18.5
Direction of principal force for vehicle no. 1: 3\3\270
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 78
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 0,9.1,8.6,8.7,8.3,0
Damage midpoint offset for vehicle no. 1: 0\0\-11.1
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

CITATION - LOW SPEED - D=COG
VEHICLE TYPES :       3     7
VEHICLE WEIGHTS:     2784.00    3229.00
VEHICLE DAMAGE INDICES: 09LDEW2     12FDEW1
COLLISION SPEEDS:        0.00     325.60
A(2),B(2),G(2):        0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:      270.00     360.00
V1 DAMAGE DATA:     78.00          0.00       9.10       8.60       8.70       8.30       0.00     -11.62
V2 DAMAGE DATA:      0.00          0.00       0.00       0.00       0.00       0.00       0.00       0.00
GAM(1:2):        0.96       1.00
ENERGY(2):        0.00
DELV1:    171.12
SUMENG:   200715.16
ENERGY(1):  200715.16
ALPHA1,BETA1:         541.32     2152.78

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: LTD - LOW SPEED - D=COG
Size category vehicle no. 1: 4
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 3554
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 09LDEW2
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 20.9
Direction of principal force for vehicle no. 1: 270
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 85.3
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 0,6.7,6.0,6.2,6.1,0
Damage midpoint offset for vehicle no. 1: -4.9
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0


 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

LTD - LOW SPEED - D=COG
VEHICLE TYPES :      4     7
VEHICLE WEIGHTS:     3554.00   3237.00
VEHICLE DAMAGE INDICES: 09LDEW2    12FDEW1
COLLISION SPEEDS:        0.00    367.84
A(2),B(2),G(2):        0.00      0.00      0.00
DIRECTION OF PRINCIPAL FORCE:      270.00    360.00
V1 DAMAGE DATA:    85.30      0.00      6.70      6.00      6.20      6.10      0.00      -5.45
V2 DAMAGE DATA:     0.00      0.00      0.00      0.00      0.00      0.00      0.00       0.00
GAM(1:2):       0.99      1.00
ENERGY(2):       0.00
DELV1:   174.67
SUMENG:   295487.09
ENERGY(1):  295487.09
ALPHA1,BETA1:         426.50      1217.80

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: N-COMP CITATION - LOW SPEED - D=COG
Size category vehicle no. 1: 3
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2602
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 09LDEW2
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 18.1
Direction of principal force for vehicle no. 1: 270
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 67
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 2.7,6.2,6.2,5.8,3.9,1.4
Damage midpoint offset for vehicle no. 1: 13.5
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

N-COMP CITATION - LOW SPEED - D=COG
VEHICLE TYPES :      3    7
VEHICLE WEIGHTS:    2602.00   3237.00
VEHICLE DAMAGE INDICES: 09LDEW2    12FDEW1
COLLISION SPEEDS:        0.00    318.56
A(2),B(2),G(2):        0.00      0.00      0.00
DIRECTION OF PRINCIPAL FORCE:     270.00    360.00
V1 DAMAGE DATA:    67.00          2.70      6.20      6.20      5.80      3.90      1.40       10.69
V2 DAMAGE DATA:     0.00          0.00      0.00      0.00      0.00      0.00      0.00        0.00
GAM(1:2):       0.97      1.00
ENERGY(2):       0.00
DELV1:   173.30
SUMENG:   185875.45
ENERGY(1):  185875.45
ALPHA1,BETA1:        323.61      848.51

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? N
```

```
Title: ESCORT - HI SPEED S.\.\M. L - D-\-\=COG
Size category vehicle no. 1: 1
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 1985
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 03RDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 32.2
Direction of principal force for vehicle no. 1: 90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 85
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 6.6,20.1,19.8,20.0,20.0,6.6
Damage midpoint offset for vehicle no. 1: -17.6
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

ESCORT - HI SPEED SM. L - D=COG
VEHICLE TYPES :      1     7
VEHICLE WEIGHTS:     1985.00   3237.00
VEHICLE DAMAGE INDICES: 03RDEW5    12FDEW1
COLLISION SPEEDS:        0.00    566.72
A(2),B(2),G(2):        0.00      0.00      0.00
DIRECTION OF PRINCIPAL FORCE:      90.00    360.00
V1 DAMAGE DATA:    85.00          6.60     20.10     19.80     20.00     20.00      6.60     -17.61
V2 DAMAGE DATA:     0.00          0.00      0.00      0.00      0.00      0.00      0.00      0.00
GAM(1:2):        0.87       1.00
ENERGY(2):        0.00
DELV1:   320.58
SUMENG:   466652.81
ENERGY(1):  466652.81
ALPHA1,BETA1:       1470.50    13423.94

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: ESCORT - HI SPEED - LG. L - D=COG
Size category vehicle no. 1: 1
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 1985
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 03RDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 32.2
Direction of principal force for vehicle no. 1: 90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 102
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 3.2,19.0,19.2,19.7,18.6,3.2
Damage midpoint offset for vehicle no. 1: -14.6
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

ESCORT - HI SPEED - LG. L - D=COG
VEHICLE TYPES :      1     7
VEHICLE WEIGHTS:     1985.00   3237.00
VEHICLE DAMAGE INDICES: 03RDEW5     12FDEW1
COLLISION SPEEDS:        0.00     566.72
A(2),B(2),G(2):        0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:       90.00     360.00
V1 DAMAGE DATA:   102.00          3.20      19.00      19.20      19.70      18.60       3.20      -14.69
V2 DAMAGE DATA:     0.00          0.00       0.00       0.00       0.00       0.00       0.00        0.00
GAM(1:2):        0.90       1.00
ENERGY(2):        0.00
DELV1:   329.34
SUMENG:    479403.91
ENERGY(1):  479403.91
ALPHA1,BETA1:        1625.88    14203.98

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: TREDIA - HI SPEED - SM. L - D=COG
Size category vehicle no. 1: 2
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2161
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 03RDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 33.5
Direction of principal force for vehicle no. 1: 90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 81
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 4.1,14.4,15.7,14.7,13.5,4.1
Damage midpoint offset for vehicle no. 1: -15.8
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

TREDIA - HI SPEED - SM. L - D=COG
VEHICLE TYPES :      2    7
VEHICLE WEIGHTS:    2161.00   3237.00
VEHICLE DAMAGE INDICES: 03RDEW5    12FDEW1
COLLISION SPEEDS:        0.00     589.60
A(2),B(2),G(2):        0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:      90.00     360.00
V1 DAMAGE DATA:    81.00         4.10      14.40      15.70      14.70      13.50       4.10      -16.28
V2 DAMAGE DATA:     0.00         0.00       0.00       0.00       0.00       0.00       0.00        0.00
GAM(1:2):       0.92      1.00
ENERGY(2):       0.00
DELV1:   335.49
SUMENG:   553132.25
ENERGY(1):  553132.25
ALPHA1,BETA1:       1010.88      6770.82

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: TREDIA - HI SPEED - LG. L - D=COG
Size category vehicle no. 1: 2
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2161
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 03RDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 33.5
Direction of principal force for vehicle no. 1: 90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 99.5
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 0.7,11.9,16.0,14.4,13.3,0.7
Damage midpoint offset for vehicle no. 1: -12.8
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

TREDIA - HI SPEED - LG. L - D=COG
VEHICLE TYPES :      2    7
VEHICLE WEIGHTS:     2161.00   3237.00
VEHICLE DAMAGE INDICES: 03RDEW5    12FDEW1
COLLISION SPEEDS:        0.00     589.60
A(2),B(2),G(2):        0.00      0.00       0.00
DIRECTION OF PRINCIPAL FORCE:       90.00    360.00
V1 DAMAGE DATA:    99.50          0.70      11.90      16.00      14.40      13.30      0.70      -12.34
V2 DAMAGE DATA:     0.00          0.00       0.00       0.00       0.00       0.00      0.00        0.00
GAM(1:2):        0.95       1.00
ENERGY(2):        0.00
DELV1:    342.95
SUMENG:    565426.13
ENERGY(1):  565426.13
ALPHA1,BETA1:        1120.37     7278.96

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: CITATION - HI SPEED - SM. L - D=COG
Size category vehicle no. 1: 3
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2420
Weight of vehicle no. 2: 3168
Vehicle damage indice no. 1: 09LDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 35.2
Direction of principal force for vehicle no. 1: 270
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 81.5
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 5.2,19.6,18.1,16.9,17.0,5.2
Damage midpoint offset for vehicle no. 1: -9.5\5.9-\-15.0
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

CITATION - HI SPEED - SM. L - D=COG
VEHICLE TYPES :      3    7
VEHICLE WEIGHTS:     2420.00   3168.00
VEHICLE DAMAGE INDICES: 09LDEW5    12FDEW1
COLLISION SPEEDS:        0.00    619.52
A(2),B(2),G(2):        0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:      270.00     360.00
V1 DAMAGE DATA:    81.50          5.20      19.60      18.10      16.90      17.00      5.20      -15.96
V2 DAMAGE DATA:     0.00          0.00       0.00       0.00       0.00       0.00      0.00        0.00
GAM(1:2):       0.93      1.00
ENERGY(2):       0.00
DELV1:    336.61
SUMENG:    653023.81
ENERGY(1):   653023.81
ALPHA1,BETA1:        1251.84    10228.55

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: CITATION - HI SPEED - LG. L - D=COG
Size category vehicle no. 1: 3 \ \
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2429\9\0
Weight of vehicle no. 2: 3168
Vehicle damage indice no. 1: 09LDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 35.2
Direction of principal force for vehicle no. 1: 270
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 100
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 1.8,17.5,17.0,17.5,10.0,1.8
Damage midpoint offset for vehicle no. 1: -9.5
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

CITATION - HI SPEED - LG. L - D=COG
VEHICLE TYPES :      3    7
VEHICLE WEIGHTS:    2420.00   3168.00
VEHICLE DAMAGE INDICES: 09LDEW5    12FDEW1
COLLISION SPEEDS:        0.00    619.52
A(2),B(2),G(2):        0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:      270.00    360.00
V1 DAMAGE DATA:   100.00          1.80      17.50      17.00      17.50      10.00       1.80      -12.95
V2 DAMAGE DATA:     0.00          0.00       0.00       0.00       0.00       0.00       0.00        0.00
GAM(1:2):       0.95      1.00
ENERGY(2):        0.00
DELV1:   341.46
SUMENG:   662434.06
ENERGY(1):  662434.06
ALPHA1,BETA1:       1276.00     9429.93

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: LTD - HI SPEED - SM. L - D=COG
Size category vehicle no. 1: 4
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 255\552\3554
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 03RDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 42.1
Direction of principal force for vehicle no. 1: 90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 111.5
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 4.1,18.9,20.5,14.8,17.9,4.1
Damage midpoint offset for vehicle no. 1: -1.2
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 === INPUT DATA AND CRUSH ROUTINE RESULTS ====

LTD - HI SPEED - SM. L - D=COG
VEHICLE TYPES :       4     7
VEHICLE WEIGHTS:     3554.00   3237.00
VEHICLE DAMAGE INDICES: 03RDEW5    12FDEW1
COLLISION SPEEDS:         0.00    740.96
A(2),B(2),G(2):         0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:       90.00     360.00
V1 DAMAGE DATA:    111.50          4.10      18.90      20.50      14.80      17.90      4.10       -2.47
V2 DAMAGE DATA:      0.00          0.00       0.00       0.00       0.00       0.00      0.00        0.00
GAM(1:2):        1.00       1.00
ENERGY(2):        0.00
DELV1:   352.91
SUMENG:  1202568.88
ENERGY(1): 1202568.88
ALPHA1,BETA1:       1699.26    14027.03

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: LTD - HI SPEED - LG. L - D=COG
Size category vehicle no. 1: 4
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 3554
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 03RDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 42.1
Direction of principal force for vehicle no. 1: 90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 138.5
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 1.0,8.2,21.1,14.7,12.4,1.0
Damage midpoint offset for vehicle no. 1: 0.1
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

LTD - HI SPEED - LG. L - D=COG
VEHICLE TYPES :       4     7
VEHICLE WEIGHTS:     3554.00    3237.00
VEHICLE DAMAGE INDICES: 03RDEW5     12FDEW1
COLLISION SPEEDS:          0.00     740.96
A(2),B(2),G(2):          0.00        0.00        0.00
DIRECTION OF PRINCIPAL FORCE:        90.00     360.00
V1 DAMAGE DATA:    138.50            1.00        8.20       21.10       14.70       12.40        1.00          1.60
V2 DAMAGE DATA:      0.00            0.00        0.00        0.00        0.00        0.00        0.00          0.00
GAM(1:2):        1.00        1.00
ENERGY(2):         0.00
DELV1:    353.07
SUMENG:  1203115.50
ENERGY(1): 1203115.50
ALPHA1,BETA1:          1589.98     11323.16

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: N-COMP CITATION - HI SPEED - SM. L - D-COG
Size category vehicle no. 1: 3
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2602
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 03RYEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 36.0
Direction of principal force for vehicle no. 1: 0\0\90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 107.5
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 0,5.1,16.0,12.2,6.9,0
Damage midpoint offset for vehicle no. 1: 8.5
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

N-COMP CITATION - HI SPEED - SM. L - D=C
VEHICLE TYPES :      3    7
VEHICLE WEIGHTS:     2602.00   3237.00
VEHICLE DAMAGE INDICES: 03RYEW5    12FDEW1
COLLISION SPEEDS:        0.00    633.60
A(2),B(2),G(2):        0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:       90.00     360.00
V1 DAMAGE DATA:   107.50          0.00       5.10      16.00      12.20       6.90       0.00        8.93
V2 DAMAGE DATA:     0.00          0.00       0.00       0.00       0.00       0.00       0.00        0.00
GAM(1:2):        0.98       1.00
ENERGY(2):        0.00
DELV1:   346.64
SUMENG:   739501.25
ENERGY(1):  739501.25
ALPHA1,BETA1:          864.30     4722.48

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: N-COMP CITATION - HI SPEED - LG. L - D=COG
Size category vehicle no. 1: 3
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2602
Weight of vehicle no. 2: 3237
Vehicle damage indice no. 1: 03RYEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 36.0
Direction of principal force for vehicle no. 1: 90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 120
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 0,2.7,17.6,13.8,7.4,0
Damage midpoint offset for vehicle no. 1: 5.3
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



  === INPUT DATA AND CRUSH ROUTINE RESULTS ===

N-COMP CITATION - HI SPEED - LG. L - D=C
VEHICLE TYPES :      3    7
VEHICLE WEIGHTS:    2602.00   3237.00
VEHICLE DAMAGE INDICES: 03RYEW5    12FDEW1
COLLISION SPEEDS:        0.00    633.60
A(2),B(2),G(2):        0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:      90.00    360.00
V1 DAMAGE DATA:   120.00          0.00       2.70      17.60      13.80       7.40       0.00        8.28
V2 DAMAGE DATA:     0.00          0.00       0.00       0.00       0.00       0.00       0.00        0.00
GAM(1:2):       0.98       1.00
ENERGY(2):       0.00
DELV1:   347.28
SUMENG:   740864.13
ENERGY(1):  740864.13
ALPHA1,BETA1:        996.00     6068.08

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: 25 MPH CITATION - VRTC - D=COG
Size category vehicle no. 1: 3
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2784
Weight of vehicle no. 2: 3229
Vehicle damage indice no. 1: 03RDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 46.6
Direction of principal force for vehicle no. 1: 90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 97
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 7.0,10.7,29.9,28.6,28.1,7.0
Damage midpoint offset for vehicle no. 1: -14.4
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

25 MPH CITATION - VRTC - D=COG
VEHICLE TYPES :       3     7
VEHICLE WEIGHTS:     2784.00   3229.00
VEHICLE DAMAGE INDICES: 03RDEW5    12FDEW1
COLLISION SPEEDS:        0.00     820.16
A(2),B(2),G(2):         0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:       90.00     360.00
V1 DAMAGE DATA:     97.00           7.00      10.70      29.90      28.60      28.10      7.00      -9.67
V2 DAMAGE DATA:      0.00           0.00       0.00       0.00       0.00       0.00      0.00       0.00
GAM(1:2):        0.97       1.00
ENERGY(2):        0.00
DELV1:    433.88
SUMENG:  1281943.13
ENERGY(1): 1281943.13
ALPHA1,BETA1:        2023.42    24510.19

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: 25 MPH CITATION - SM. L - D=COG
Size category vehicle no. 1: 3
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2784
Weight of vehicle no. 2: 3229
Vehicle damage indice no. 1: 03RDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 46.6
Direction of principal force for vehicle no. 1: 90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 91.5
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 9.3,12.0,28.1,28.2,26.7,9.3
Damage midpoint offset for vehicle no. 1: -21.9
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0



 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

25 MPH CITATION - SM. L - D=COG
VEHICLE TYPES :      3    7
VEHICLE WEIGHTS:    2784.00   3229.00
VEHICLE DAMAGE INDICES: 03RDEW5    12FDEW1
COLLISION SPEEDS:       0.00    820.16
A(2),B(2),G(2):        0.00       0.00       0.00
DIRECTION OF PRINCIPAL FORCE:      90.00    360.00
V1 DAMAGE DATA:    91.50         9.30     12.00     28.10     28.20     26.70     9.30     -18.02
V2 DAMAGE DATA:     0.00         0.00      0.00      0.00      0.00      0.00     0.00       0.00
GAM(1:2):       0.91      1.00
ENERGY(2):        0.00
DELV1:   418.47
SUMENG:  1236414.75
ENERGY(1): 1236414.75
ALPHA1,BETA1:       1908.69    22261.74

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? Y
```

```
Title: 25 MPH CITATION - LG. L - D=COG
Size category vehicle no. 1: 3
Size category vehicle no. 2: 7
Weight of vehicle no. 1: 2784
Weight of vehicle no. 2: 3229
Vehicle damage indice no. 1: 03RDEW5
Vehicle damage indice no. 2: 12FDEW1
Impact speed vehicle no. 1 (mph): 0
Impact speed vehicle no. 2 (mph): 46.6
Direction of principal force for vehicle no. 1: 90
Direction of principal force for vehicle no. 2: 360
Damage width for vehicle no. 1: 116.5
Number of damage depth profiles for vehicle no. 1 (2,4, or 6): 6
Damage depth profile for vehicle no. 1: 2,22.6,28.9,30.7,12.2,2
Damage midpoint offset for vehicle no. 1: -9.9
Damage width for vehicle no. 2: 0
Number of damage depth profiles for vehicle no. 2 (2,4, or 6): 2
Damage depth profile for vehicle no. 2: 0,0
Damage midpoint offset for vehicle no. 2: 0




 ==== INPUT DATA AND CRUSH ROUTINE RESULTS ====

25 MPH CITATION - LG. L - D=COG
VEHICLE TYPES :      3    7
VEHICLE WEIGHTS:     2784.00   3229.00
VEHICLE DAMAGE INDICES: 03RDEW5    12FDEW1
COLLISION SPEEDS:        0.00    820.16
A(2),B(2),G(2):        0.00      0.00      0.00
DIRECTION OF PRINCIPAL FORCE:      90.00    360.00
V1 DAMAGE DATA:    116.50          2.00      22.60      28.90      30.70      12.20      2.00      -13.45
V2 DAMAGE DATA:      0.00          0.00       0.00       0.00       0.00       0.00      0.00        0.00
GAM(1:2):        0.95      1.00
ENERGY(2):        0.00
DELV1:   427.92
SUMENG:  1264327.13
ENERGY(1): 1264327.13
ALPHA1,BETA1:       2246.12    26667.28

Do you want this data entered into your data set
to calculate A and B values (Y/N)? N
Run again (Y/N)? N
You must now input the parameter list for A and B values.
This will put a range around a guess value of A and B.
Make sure to select a range that will encompass the actual
value you are seeking. Now enter low range value of A, high
range value of A, low range value of B, high range value
of B. Separate with commas and enter in integer form.
EXAMPLE: For a guess value of A=250 and B=49,
Enter: 200,300,40,60
Enter: 0,0,0,0

Be sure to list CRUSH1.DAT, before you submit it.
If you want to edit it type: EDIT CRUSH1.DAT
FORTRAN STOP
$ LOG
  WILLKE       logged out at 18-NOV-1986 15:15:49.08
```

APPENDIX D

Alternate Crush Measurements and Stiffness Parameters

RANGE OF DAMAGE MEASUREMENTS

Vehicle	Damage Measurements (inches)							
	L	C1	C2	C3	C4	C5	C6	D
Escort								
sm. L	85.0	6.6	20.1	19.8	20.0	20.0	6.6	-17.6
lg. L	102.0	3.2	19.0	19.2	19.7	18.6	3.2	-14.6
Tredia								
sm. L	81.0	4.1	14.4	15.7	14.7	13.5	4.1	-15.8
lg. L	99.5	0.7	11.9	16.0	14.4	13.3	0.7	-12.8
Citation								
sm. L	81.5	5.2	19.6	18.1	16.9	17.0	5.2	-15.0
lg. L	100.0	1.8	17.5	17.0	17.5	10.0	1.8	-9.5
LTD								
sm. L	111.5	4.1	18.9	20.5	14.8	17.9	4.1	-1.2
lg. L	138.5	1.0	8.2	21.1	14.7	12.4	1.0	0.1
non-comp. Citation								
sm. L	107.5	0.0	5.1	16.0	12.2	6.9	0.0	8.5
lg. L	120.0	0.0	2.7	17.6	13.8	7.4	0.0	5.3
25 mph Citation								
sm. L	91.5	9.3	12.0	28.1	28.2	26.7	9.3	-21.9
lg. L	116.5	2.0	22.6	28.9	30.7	12.2	2.0	-9.9

TL 242 .W533 1987 v. 2

Willke, Donald T.

CRASH III model improveme

Form DOT F 1720.2 (8-70)
FORMERLY FORM DOT F 1700.11.1

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