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WEIGHT REDUCTION POTENTIAL OF AUTOMOBILES AND LIGHT TRUCKS

1979 Summary Source Document

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WEIGHT REDUCTION POTENTIAL OF AUTOMOBILES AND LIGHT TRUCKS, 1979 SUMMARY SOURCE DOCUMENT.

March 1980, 204 pp.

Please be advised that the following page, hereto attached, replaces page xiv in the above document.

Thank you

Attachment
1 page

TABLE E-1. MATERIALS USED FOR VARIOUS VEHICLE COMPONENTS FOR THE CASES CONSIDERED

VEHICLE COMPONENT	HSS DOMINANT CASE	FRP DOMINANT CASE	ALUMINUM DOMINANT CASE	HRP DOMINANT CASE
Body Panels	HSS	FRP	Aluminum	HRP
Structural Parts	HSS	HSS	HSS	HRP
Engine Block	Cast Iron	Cast Iron	Aluminum	Aluminum
Wheels	Aluminum	HRP	Aluminum	HRP

PREFACE

This report, DOT-TSC-NHTSA-79-54, "Weight Reduction Potential of Automobiles and Light Trucks, 1979 Summary Source Document," provides an assessment of the potential for weight reduction (as of the end of fiscal year 1979) for passenger cars and light trucks in the 1980 to 2000 time frame.

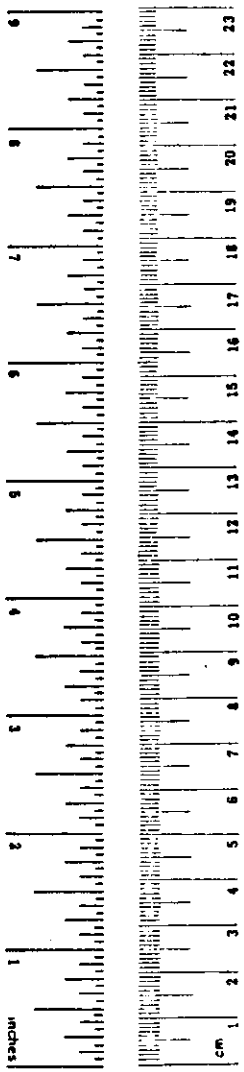
The Summary Source Document is a deliverable under PPA HS-927, "Support for Research and Analysis in Auto Fuel Economy and Related Areas."

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

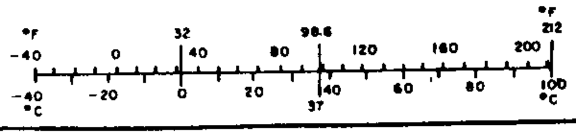
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

This report presents the methodology and results of a study conducted to evaluate the potential of weight reduction for passenger cars and light trucks by material substitution. The vehicles included in this study are four-, five-, and six-passenger cars for the passenger car fleet, and pickups, vans, and utility vehicles, up to 8500 pounds GVWR, for the light truck fleet. The alternative materials considered for the substitution are high strength steels (HSS), aluminum, fiberglas reinforced plastic (FRP), and hybrid reinforced plastic (HRP), which contains 20 percent graphite and 80 percent glass.

Vehicles of weight efficient design are selected as baseline vehicles for this study. These vehicles are the 1978 Chrysler Omni, the 1978 Ford Fairmont and the 1977 Chevrolet Impala, representing four-, five-, and six-passenger cars, respectively, and the 1978 Dodge D 100, the 1978 Dodge B 100, and the 1978 Dodge Ramcharger, representing pickups, vans, and utility vehicles, respectively. Detailed component material and weight data for these vehicles are obtained from vehicle tear-down studies.

For each baseline vehicle, components, which are judged to be replaceable by the material, differ only in the material selected. Four cases of material substitution were considered: the HSS dominant case, the FRP dominant case, the aluminum dominant case, and the HRP dominant case. The materials used for various components in each case are shown in the following Table E-1. In all four cases, the vehicles are assumed to have aluminum cylinder heads, stainless steel exhaust manifolds, HRP springs, foam or aluminum bumpers and high density polyethylene (HDPE) fuel tanks.

Because of the large number of vehicle components involved, it is necessary to establish a simplified approach to classify these components by their geometrical shapes into three groups, panels, thin-walled beams, and solid sections. The components made of substitutional material are assumed to have the same overall dimensions and geometry as the original ones except for possible changes

TABLE E-1. MATERIALS USED FOR VARIOUS VEHICLE COMPONENTS FOR THE CASES CONSIDERED in thickness.

Studies show that stiffness is the most restrictive structural requirement of the total vehicle and its components for direct material substitution. Using stiffness as the component design criterion, the weight of a replacement component can be determined from the following formula:

$$W_n = W_o \left(\frac{Pn}{P_o}\right)\left(\frac{E_o}{E_n}\right)^{\frac{1}{m}}$$

where W is the weight of the component, P and E are the density and the modulus of elasticity of the material, respectively. The subscripts n and o refer to new and old material, respectively, and m is the geometric factor which is equal to 1 for thin-walled beams, 2 for panels, and 3 for solid sections.

By applying this formula, weight savings that can be achieved with the substitutional materials are computed for each baseline vehicle. The results are shown in Table E-2. The curb weights shown are the results of direct material substitution. Since a reduction in vehicle upper body weight allows a reduction in under body weight, which in turn leads to a reduction in the weight of chassis components, for every pound of primary weight reduction there is a secondary weight reduction. This secondary weight reduction ranges from a low estimate of 0.4 pounds to a high assessment of 1.6 pounds per pound of primary weight change. However, these estimates are based on statistical analyses performed on vehicle weight data for pre-1975 models. Since then, vehicle weight has been greatly reduced by resizing, material substitution and redesign. It is doubtful that these estimates derived from pre-1975 weight data can be used to accurately project secondary weight change for present vehicles, let alone for vehicles in the future. For this reason, an analytical methodology based on component structural characteristics and change in applied load is being developed for determining secondary weight reduction.

TABLE E-2. CURB WEIGHT REDUCTION AFTER MATERIAL SUBSTITUTION

Baseline Vehicle	CURB WEIGHT* (LB) Original	HSS Dominant	FRP Dominant	Aluminum Dominant	HRP Dominant
4-Passenger Car	2020	1821	1794	1691	1467
5-Passenger Car	2699	2322	2301	2214	1856
6-Passenger Car	3598	3022	2979	2781	2429
Pickup	3572	3029	2981	2775	2456
Van	3432	3860	2813	2606	2293
Utility	4277	3709	3668	3394	3216

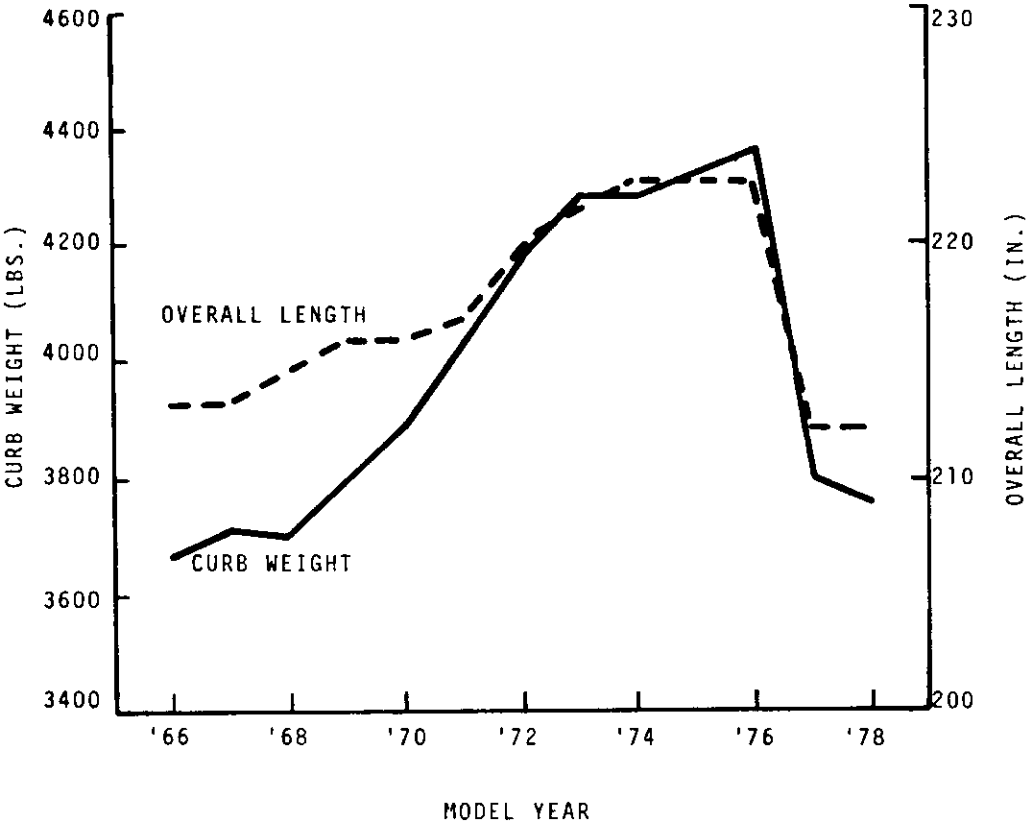
*Less Fuel

1. INTRODUCTION

1.1 BACKGROUND

The American car has grown steadily in curb weight and overall length from the early 1950's to 1976. This trend is best represented by the best selling fullsize Chevrolet which grew about 700 pounds in weight and nearly one foot in length in the period between 1967 and 1976, as shown in Figure 1-1. Since a major portion of the power required to move a vehicle is utilized to overcome rolling resistance which is a direct function of vehicle weight, vehicle fuel economy deteriorates with increases in vehicle weight. Analyses show that among the many factors that influence vehicle fuel economy, vehicle weight is the most significant.[1] A 10 percent reduction in vehicle weight can result in an improvement in fuel economy from a modest 2 to 3 percent to a very substantial 8 to 9 percent, depending on how the weight reduction is accomplished.[3]

In an attempt to conserve energy, Congress passed the Energy Policy and Conservation Act of 1975. This law requires each automobile manufacturer to meet or surpass a CAFE (Corporate Average Fuel Economy) value of 27.5 mpg by 1985 (Table 1-1). As the result of this mandate, reduction of vehicle weight has become a priority in the automotive industry. General Motors was the first among the domestic automobile manufacturers to initiate a series of vehicle weight reduction programs. These programs led to the introduction of the downsized fullsize cars in 1977 and the downsized midsize cars in 1978; both were several hundred pounds lighter and about a foot shorter than the previous models. Despite the reduction in weight and size, the available space for occupants remained nearly unchanged for these new models. For the 1980 model year, front-wheel drive compact size X-body cars with transverse-mounted engines have been introduced. The new models have a curb weight of 2500 pounds and an overall length of 177 inches (as compared to 3260 pounds in weight and 200 inches in



Source: Reference 1.

FIGURE 1-1. CURB WEIGHT AND OVERALL LENGTH OF FULLSIZE CHEVROLET WITH V-8 ENGINE

TABLE 1-1. FLEET AVERAGE FUEL ECONOMY STANDARDS

MODEL YEAR	FUEL ECONOMY STANDARDS (MPG) PASSENGER CARS	LIGHT TRUCKS (up to 8500 lb GVWR) 4x2	4x4
1978	18.0		
1979	19.0	17.2*	15.8*
1980	20.0	16.0	14.0
1981	22.0	16.7	15.0
1982	24.0		
1983	26.0		
1984	27.0		
1985	27.5		

*For trucks up to 6000 lb GVWR only.

overall length for the previous models). GM reportedly will begin another round of downsizing for full size and midsize cars in the mid 1980's, and the midsize cars will probably be front-wheel drive.

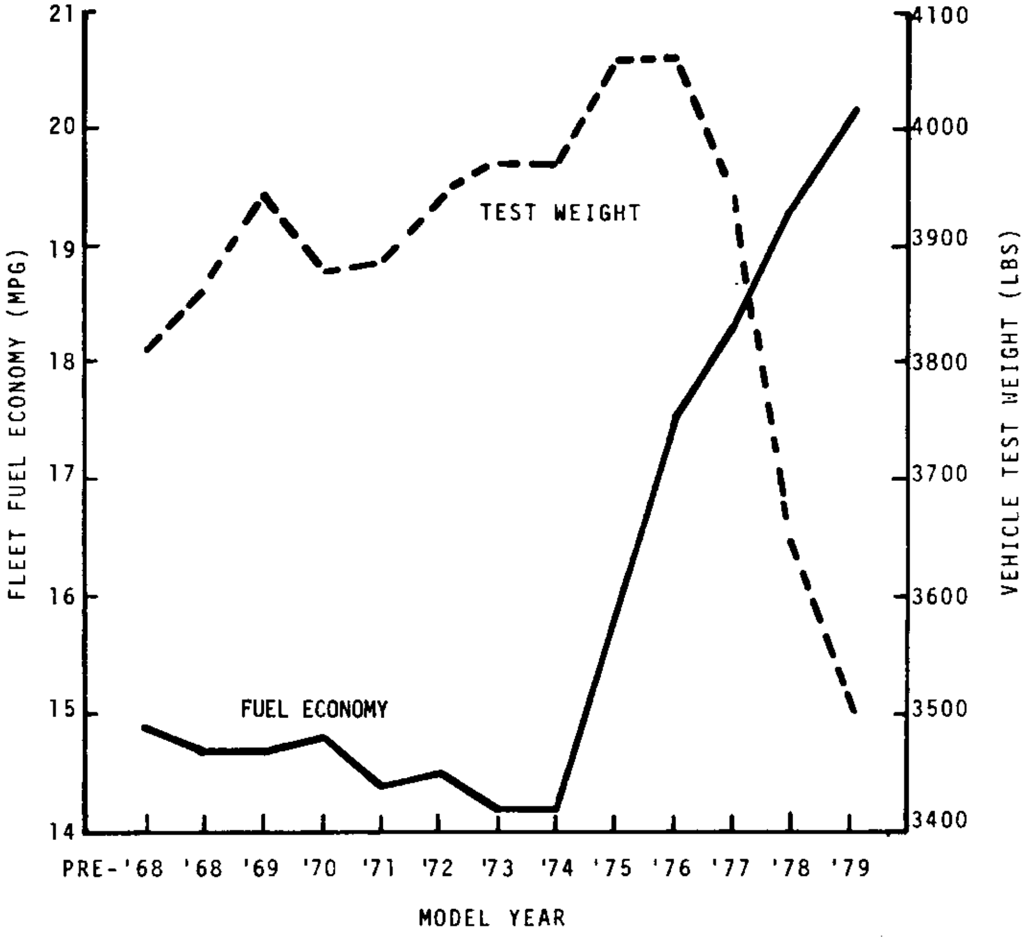
Ford and Chrysler began their weight reduction program by downsizing their 1979 fullsize vehicles. Both companies are expected to downsize their midsize cars in the early 1980's. Some of these midsize cars probably will be front-wheel drive.

As the result of vehicle downsizing and the introduction of more weight efficient new models, the industry averaged vehicle test weight was drastically reduced from the weight of 4060 pounds in 1976 to 3508 pounds in 1979.[4] Corresponding to this change in weight is the 2.6 mpg increase in fleet fuel economy in this period according to EPA. Figure 1-2 shows the trends in fleet fuel economy and test weight in the period between 1968 and 1979 as reported by Murrell of EPA.[4]

Compared to passenger cars, very little progress in weight reduction has been made for light trucks of GVWR up to 8500 pounds. The primary reason is that the difference between actual size and functional size which existed in the passenger cars does not exist to the same degree on trucks. Therefore, a similar magnitude of weight reduction by downsizing does not apply to trucks. Secondarily, the required functional and performance attributes for light trucks are not yet clearly defined. For passenger cars, the major attributes as perceived by the consumer are roominess and acceleration capability. In the case of light trucks, the attributes probably include load capacity, volume capacity, acceleration, gradeability, road clearance, and the ability to accommodate different road or terrain conditions. Therefore, there are many more constraints for light truck weight reduction than for passenger cars.

1.2 PURPOSE OF DOCUMENT

The purpose of this document is to evaluate the potential weight reduction for passenger cars and light trucks of GVWR up to 8500 pounds in the period between 1980 and 2000. The vehicles



SOURCE: REFERENCE 4.

FIGURE 1-2. TRENDS IN SALES-WEIGHTED FLEET FUEL ECONOMY AND VEHICLE TEST WEIGHT under consideration are 4-, 5-, and 6-passenger cars for the passenger car fleet; and the pickups, vans, and utility vehicles for the light truck fleet. In addition, this document will establish methodologies for the assessment of weight reduction potential and define the relevant issues and impacts that are likely to arise.

2. DESCRIPTION OF VEHICLE ATTRIBUTES

Because of their distinct functional requirements, passenger cars and light trucks are characterized by different physical and performance attributes. This section presents descriptions of major vehicle attributes to provide a meaningful characterization for these two types of vehicles.

2.1 PASSENGER CAR ATTRIBUTES

In this document, passenger cars are defined as motor vehicles which have four wheels and are designed primarily for use on the public streets, roads, and highways for carrying six passengers or less. Military and recreational vehicles are not included.

Vehicle attributes which concern the consumers of passenger cars include volume (passenger) capacity, fuel economy, performance, engine and transmission type, appearance, initial cost, safety, durability, etc. Of these, volume capacity and vehicle performance are the most important measures of vehicle utility to the passenger car buyers.

2.1.1 Volume Capacity

For passenger cars, volume capacity is defined by EPA as the interior volume of passenger and cargo compartment. The volume of the passenger compartment is the sum of the products of the height, length, and width of front and rear seats. The formulas for calculating model year 1977 interior volume are shown in Table 2-1.

Based on the measurement of the interior volume of the vehicle, EPA classifies passenger vehicles into four classes for sedans (including two seaters), and three classes for station wagons, as shown in Table 2-2. Some changes in interior volume measurement have been made for the 1978 model year to bring the classification system more in line with what consumers view as comparable groupings.[5]

TABLE 2-1. FORMULAS FOR VOLUME CALCULATION

$$\text{Sedan Vol.}(ft^3) = \underbrace{\frac{H61 \times L34 \times W3}{1728}}_{\text{Front Seat}} + \underbrace{\frac{H63 \times L51 \times W4}{1728}}_{\text{Rear Seat}} + \underbrace{V_1}_{\text{Cargo}}$$

Hatchback Vol.(ft^3) = Same as Sedan + V_3

Station Wagon Vol.(ft^3) = Same as Sedan + V_2

Where V_1 = determined with luggage set as specified in J1100(a)

$$V_2 = \frac{W4 \times H201 \times L205}{1728}$$

$$V_3 = \frac{W4 \times H197 \times \left(\frac{L208 + L209}{2}\right)}{1728}$$

Note: All measurements as specified in SAE Procedure J1100(a) except H197 is to top of second seat and L208 and L209 are to the back of the second seat. All measurements in inches.

TABLE 2-2. VEHICLE CLASSIFICATION BY INTERIOR VOLUME

Vehicle Class	Interior Volume (ft^3)
Sedans	
Minicompacts	Under 85
Subcompact	85 - 100
Compact	100 - 110
Midsize	110 - 120
Large	Over 120
Station Wagons	
Small	Under 130
Midsize	130 - 160
Large	Over 160

2.1.2 Roominess Index

Roominess index is another measure of vehicle functional size. It is defined as the sum of seven principal interior dimensions in inches. These dimensions are front seat height, front and rear headroom, front and rear leg room, and front and rear shoulder room.

The ranges of roominess index for seven groups of 1979 domestic passenger vehicles as determined by Automotive Industries[6] are shown in Table 2-3.

TABLE 2-3. CLASSIFICATION OF 1979 DOMESTIC PASSENGER VEHICLES BY ROOMINESS INDEX

Vehicle Class	Roominess Index (IN.)
Mini Compact	260.4
Subcompact	252.8 - 273.4
Compact	268.6 - 275.9
Intermediate	274.9 - 280.6
Standard	286.7 - 290.4
Luxury	286.5 - 292.0
Personal Luxury	132.2 - 279.0

It can be seen that there is a considerable overlap of roominess index between vehicle classes. This grouping of vehicles was based less on vehicle roominess and more on the vehicle's outer size and prestige as perceived by the consumers.

2.1.3 Inertia Weight

Inertia weight of a vehicle is defined by the EPA to be vehicle curb weight plus 300 pounds. Vehicle curb weight is, in turn, defined as the weight of a vehicle with maximum capacity of engine fuel, oil, and coolant and with the full weight of all items of optional equipment sold on 33 percent or more of that vehicle family.

Inertia weight is used to simulate the test weight of a vehicle during acceleration and deceleration. For testing purpose, it is grouped into classes with 125, 250 and 500 pounds increments. Table 2-4 shows inertia weight classes for vehicles up to 10,000 pounds inertia weight.

2.1.4 Acceleration

A simple measure of vehicle acceleration performance is the 0 to 60 mph acceleration time. The acceleration time can be related to vehicle horsepower-to-weight ratio (HP/WT) which is defined as the ratio of maximum engine brake horsepower to vehicle inertia weight. It is recognized that there are several factors affecting vehicle acceleration time besides HP/WT. Not only are engine speed-torque characteristics and drivetrain characteristics significant factors, but human reactions, and test track conditions also can have appreciable affects on the measurement of acceleration time. Nevertheless, HP/WT is overwhelmingly influential and allows an adequate description of the acceleration performance.

An analysis[7] using test track measurements of 1975 vehicles relates HP/WT to 0-60 MPH acceleration time as follows

$$t = 0.829\ (HP/WT)^{-.819}$$

where:

t is 0-60 MPH acceleration time in seconds.

According to this formula, HP/WT values of 0.02, 0.03 and 0.04 result in 0-60 MPH acceleration time of 20, 15 and 12 seconds, respectively. These three levels of acceleration performance are designated as low, mid, and high, respectively, in a Federal Task Force Report on Motor Vehicle Goals Beyond 1980.[8]

Acceleration data for 110 1978 passenger cars were obtained from popular automotive literature. These data as well as their relevant attributes are listed in Appendix C, Table C-1. The relationship between the 0-60 MPH time and the HP/WT ratio for

TABLE 2-4. INERTIA WEIGHT CLASSES (part 1 of 2)

INERTIA WEIGHT	INERTIA WEIGHT CLASS (LBS) 1979 AND EARLIER	INERTIA WEIGHT CLASS (LBS) 1980 AND BEYOND
UP TO 1062	1000	1000
1063 - 1187	1000	1125
1188 - 1312	1250	1250
1313 - 1437	1250	1375
1438 - 1562	1500	1500
1563 - 1687	1500	1625
1688 - 1812	1750	1750
1813 - 1937	1750	1875
1938 - 2062	2000	2000
2063 - 2187	2000	2125
2188 - 2312	2250	2250
2313 - 2437	2250	2375
2438 - 2562	2500	2500
2563 - 2687	2500	2625
2688 - 2812	2750	2750
2813 - 2937	2750	2875
2938 - 3062	3000	3000
3063 - 3187	3000	3125
3188 - 3312	3000	3250
3313 - 3437	3500	3375
3438 - 3562	3500	3500
3563 - 3687	3500	3625
3688 - 3812	3500	3750
3813 - 3937	4000	3875
3938 - 4125	4000	4000
4126 - 4375	4000	4250
4376 - 4625	4500	4500
4626 - 4875	4500	4750
4876 - 5125	5000	5000
5126 - 5375	5000	5250
5376 - 5750	5500	5500

TABLE 2-4. INERTIA WEIGHT CLASSES (part 2 of 2)

INERTIA WEIGHT	INERTIA WEIGHT CLASS (LBS) 1979 AND EARLIER	INERTIA WEIGHT CLASS (LBS) 1980 AND BEYOND
5751 - 6250	6000	6000
6251 - 6750	6500	6500
6751 - 7250	7000	7000
7251 - 7750	7500	7500
7751 - 8250	8000	8000
8251 - 8750	8500	8500
8751 - 9250	9000	9000
9251 - 9750	9500	9500
9751 - 10,000	10,000	10,000

these 1978 vehicles is determined by a least-squares fit technique to be:

$$t = .681\ (HP/WT)^{-.852}$$

2.1.5 Weight-Passenger Ratio

Another method of comparing vehicle efficiencies is by quantifying vehicle weight per passenger. Representative vehicles for six, five, four, and luxury (six) passenger cars were selected on the basis of highest sales leader within each category. The minimum curb weight for a two door model was used for each case. For comparison purposes, a representative large transit bus is included. Table 2-5 presents the results.

2.2 LIGHT TRUCKS

Light trucks are defined in this document as pickups, vans, and utility vehicles designed primarily for the transportation of cargo and personnel with gross vehicle weight ratings of 8500 pounds or less. These vehicles are intended for both on and off highway use. Military vehicles, vehicles which are exclusively for off-road use, recreation vehicles, and vehicles with a specialized body are not included in this document.

2.2.1 Gross Vehicle Weight Rating (GVWR)

Gross vehicle weight rating is defined as the maximum overall weight at which the vehicle is designed to operate. It is specified by the vehicle manufacturer and is the common measure used to classify various sizes of trucks. In this document, we consider only those light trucks with GVWR at or below 8500 pounds.

2.2.2 Payload

Payload is defined as the difference between the gross vehicle weight rating and the curb weight of the truck. It includes the weight of cargo, driver, passengers, and all extra

TABLE 2-5. VEHICLE WEIGHT-PASSENGER RATIO

VEHICLE	CURB WEIGHT (POUNDS)	PASSENGER CAPACITY	VEHICLE POUNDS/ PASSENGER
Chevrolet Impala	3,621	6	603.5
Ford Fairmont	2,706	5	541.2
Chevrolet Chevette	1,991	4	497.7
Ford Thunderbird	4,040	6	673.3
Transit Bus	23,000	51	451.0

equipment not included in curb weight. It is important to note that the weight of passengers and extra equipment must be subtracted from payload to determine the true cargo load capacity.

In the weight reduction analyses for light trucks presented in this document, vehicle payload is considered to remain unchanged. Only vehicle curb weight and GVWR are subject to change. This means that vehicles with GVWR greater than 8500 pounds before weight reduction may fall to 8500 pounds GVWR or below after weight reduction.

2.2.3 Volume Capacity

Volume capacity of a truck cannot be defined as precisely as load capacity. It is considered to be the space assigned to carrying the cargo load. In a vehicle with an open cargo area, such as a pickup, volume capacity is considered to be the volume of the cargo box, although specific loads higher than the sides of the cargo box can be carried by the vehicle. In a van type vehicle, volume capacity is considered to be the interior space behind the driver's seat.

One common requirement for cargo area is to have a minimum of four feet of clear load space between the rear wheel housings and eight feet of cargo area length. This is based on the widespread use of these dimensions as a unit size for building materials and cargo containers. These dimensions will remain unchanged in the weight reduction consideration.

2.2.4 Gradeability

Gradeability is a measure of the capability of a fully loaded truck to satisfactorily move up a specified grade from a dead stop. Ford and GM specified 17 percent and 16 percent grades, respectively.[9] Furthermore, GM stated that the requirement of 16 percent grade was generally met by vehicles having a maximum theoretical tractive force equal to 46 percent and 31 percent of the vehicle GVW for vehicles with automatic and manual transmission, respectively. The tractive force (F_T) is computed on the basis of maximum engine torque (TQ) and maximum transmission torque multiplication ratio (TR). With appropriate algebraic manipulation, this requirement can be expressed as:

$$F_T = K_T \frac{(TQ)(TR)(N/V)}{GVW}$$

where:

K_T = .155 for automatic transmission

K_T = .230 for manual transmission

and

N/V = The quotient of engine speed in RPM divided by vehicular speed in MPH measured in the highest, i.e., the lowest numerical transmission gear.

Ford also specified that a fully loaded truck should have the ability to satisfactorily climb a 27 percent grade.

2.2.5 Acceleration

The 0-60 mph acceleration time of twenty 1978 light trucks were obtained from automotive trade publications. A listing of these trucks and their performance related attributes is given in Appendix C, Table C-2.

The 0-60 mph acceleration time has been correlated to the vehicle horsepower-to-weight-ratio as follows:

$$t = .296\ (HP/WT)^{-1.13}$$

where: t = 0-60 mph acceleration time in seconds

HP = maximum engine brake horsepower

WT = vehicle inertia weight in pounds

A plot of the above relationship is given in Figure 2-1.

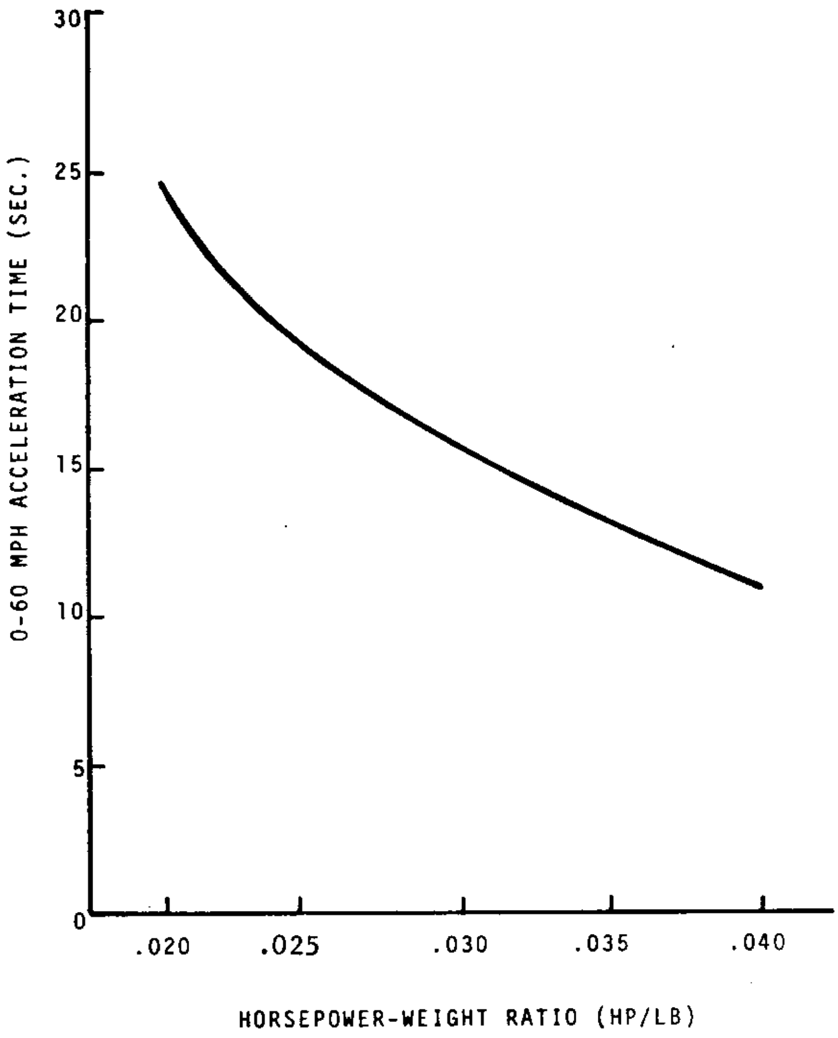


FIGURE 2-1. ACCELERATION TIME VERSUS HORSEPOWER-WEIGHT RATIO FOR 1978 LIGHT TRUCKS

3. DESCRIPTION OF AVAILABLE DATA

Weight related vehicle data used in preparing this document came from three sources: vehicle teardown data obtained through contractual work or from the automotive industry, data submitted by the automotive industry to the docket, and data reported in the automotive literature. A brief review of these data is given in the following sections.

3.1 VEHICLE TEARDOWN DATA

A vehicle teardown study provides baseline data on automotive component weights and material use. To obtain these basic data, selected vehicles were obtained and dismantled. Their various components and subassemblies were analyzed to determine the weight, material, gauge, and the manfacturing process which was used to produce the part. Table 3-1 summarizes the available passenger car and light truck teardown data. Because of their volume these teardown data will not be reprinted in this report.

3.2 DATA FROM DOCKETS

This section contains passenger and light truck information from manufacturers which has been submitted, via dockets, to the National Highway Traffic Safety Administration. Representative companies are arranged within separate industrial divisions.

3.2.1 Aluminum Manufacturers

3.3.1.1 Aluminum Company of America (ALCOA) - According to ALCOA, vehicle components which are most amenable to aluminum substitution are those which are bolted on to the vehicle chassis. Included in this category are the: air cleaner, fuel tank, battery tray, bumpers, cargo box, cowl panels, hood, doors, fenders, spare tire carrier, valve covers, dash panel, radiator support, and seat components. Other conversions could be for van roof panels, roof bows, floor pans, wheels, radiators, and heater cores.

TABLE 3-1. AVAILABLE TEARDOWN DATA (part 1 of 2)

VEHICLE DESCRIPTION	NOTE
Passenger Automobiles:	
1975 Chevelle Coupe w/250 CID engine and 3-speed automatic transmission	a
1975 Pinto 2-door Sedan 2/2.3L engine and 3-speed automatic transmission	b
1975 Audi 100LS (engine and transmission data only)	c
1976 VW Rabbit (engine and transmission data only)	c
1978 Impala 2-door Sedan w/250 CID engine and 3-speed automatic transmission	d
1978 Fairmont 4-door Sedan 2/2.3L engine and 4-speed manual transmission	e
1978 Omni 4-door hatchback w/1.7L engine and 4-speed manual transmission	f
1977 Impala 4-door (body structure data only)	g
VW Rabbit (body structure data only)	g
Pickup Trucks:	
1973 Ford F-100 Ranger w/133 inch wheelbase, 302 CID engine and manual transmission, 5000 lb GVW	h
1978 LUV Puckup w/110 CID engine, 4-speed manual transmission, 3550 GVW	i
F-250 Styleside pickup, 133 inch wheelbase (body structure data only)	g
1978 Dodge D-100 pickup w/131 inch wheelbase, 225 CID engine and 3-speed manual transmission, 5000 lb GVW (body structure and major component data)	k
Fiat 238 pickup w/88 CID engine, 4718 lb GVW (vehicle system data only)	k
Vans:	
E-150 Van, 124 inch wheelbase (body structure data only)	g
Unibody Van, 124 inch wheelbase (body structure data only)	g
1978 Dodge B-100 Van w/109 inch wheelbase, 318 CID engine and automatic transmission, 4600 lb GVW (body structure and major component data)	j

TABLE 3-1. AVAILABLE TEARDOWN DATA (part 2 of 2)

a. Development of a Motor Vehicle Materials Historical, High-Volume Industrial Processing Rates Cost Data Bank (Intermediate Type Car), Report No. DOT-HS-801 923.

b. Development of a Motor Vehicle Materials Historical, High-Volume Industrial Processing Rates Cost Data Bank (Compact-Type Car), Report No. DOT-HS-802-066.

c. Analyses of Selected Automotive Parts and Assemblies for Cost and Material Impact, Report No. DOT-TSC-NHTSA-79-19.

d. Development of a Motor Vehicle Materials Historical, High-Volume Industrial Processing Rates Cost Data Bank (5300-4000 Pound) Full Size Car, Report No. DOT-HS-803 894.

e. Ford Fairmont Weight Reduction Baseline Data, Report No. DOT-HS-803-683.

f. Weight Study 1978 Chrysler Omni, Report No. DOT-HS-804 720.

g. Progress Report for Contract No. DOT-HS-6-01479: Material Applications in Future Automotive Structures.

h. R.E. Luetje and R.L. Martin, ARMCO Steel Corporation, Light Truck Materials Evaluation, Market Development Report, Sept. 1975.

i. Chevrolet LUV Pickup Truck Weight Reduction Baseline Data, Report No. DOT-HS-803 778.

j. Light Duty Truck Weight Reduction Evaluation, Draft Final Report, Contract No. DOT-TSC-1451. Prepared by Pioneer Engineering & Manufacturing Co.

k. Light Duty Truck Weight Reduction Evaluation, Draft Final Report, Contract No. DOT-TSC-1467. Prepared by IIT Research Institute.

Two hypothetical vehicles representing pickup trucks and cargo vans in the 6000 pound GVW class are used by ALCOA to evaluate weight reduction potentials of these vehicles by aliminum substitution. For each of these hypothetical vehicles, weight savings by aluminum substitution are determined for conservative and optimum scenarios. The conservative analysis considers gauge increase for manufacturing purposes while the optimum analysis considers gauge-to-gauge substitution. Based on these analyses, weight savings of 482 and 535 pounds for the pickup truck and 389 and 434 pounds for the cargo van are derived for conservative and optimum scenarios, respectively. Detailed results of these analyses are given in Appendix D.[35]

3.2.1.2 Alcan Aluminum Corporation - Vehicular components which Alcan believes are amenable to weight reduction are: sheet metal body panels (hoods, rear decks, doors, fenders, etc.), wheels, bumpers, load floors, heat exhangers (radiators, heater cores, air conditioning components), oil pans, interior and exterior trim, miscellaneous brackets, supports and reinforcements, cast cylinder blocks and cylinder heads, pistons, intake manifolds, transmission parts, electrical wiring, and battery cables.

3.2.1.3 Kaiser Aluminum and Chemical Corporation - Kaiser distinguishes between sheet and cast aluminum nonpassenger vehicle components for both light trucks and utility vans. Table 3-2 summarizes Kaiser's projection for light truck weight reduction.[37]

3.2.1.4 Reynolds Aluminum - Information is summarized for several pickup truck components in Table 3-3.[38]

3.2.2 Chemical Companies

3.2.2.1 Allied Chemical - The only products fabricated by the Automotive Products Division of Allied Chemical and sold to automotive manufacturers are safety restraint systems. The components include retractors, buckles, chassis anchors, D-rings, and webbing.

TABLE 3-2. POTENTIAL WEIGHT REDUCTION BY ALUMINUM SUBSTITUTION

	VEHICLE COMPONENT	LIGHT TRUCK STEEL (POUNDS)	LIGHT TRUCK ALUMINUM (POUNDS)	LIGHT TRUCK SAVINGS (POUNDS)	LIGHT TRUCK % Δ	UTILITY VAN STEEL (POUNDS)	UTILITY VAN ALUMIMUN (POUNDS)	UTILITY VAN SAVINGS (POUNDS)	UTILITY VAN % Δ
SHEET METAL	LOAD BOX ASSEMBLY	350	200	150	42.8	-	-	-	-
	DOORS	80	40	40	50.0	200	100	100	50.0
	TAILGATE ASSEMBLY	45	25	20	44.4	-	-	-	-
	HOOD ASSEMBLY	75	35	40	53.3	75	35	40	-
	FENDERS	75	40	35	46.7	75	40	35	46.7
	RADIATOR SUPPORT	30	15	15	50.0	30	15	15	50.0
	RADIATOR	15	10	5	33.3	15	10	5	33.3
	SEAT FRAMES	20	10	10	50.0	20	10	10	50.0
	WHEELS	100	50	50	50.0	100	50	50	50.0
	BUMPERS AND SUPPORTS	90	45	45	50.0	90	45	45	50.0
	MISCELLANEOUS LIGHT GAUGE STAMPINGS	100	50	50	50.0	100	50	50	50.0
	MISCELLANEOUS BRACKETS	70	40	30	42.9	70	40	30	42.9
CASTINGS	ENGINE PARTS (MANIFORLD CYL. HEAD, ETC.)	130	55	75	57.7	130	55	75	57.7
	MISCELLANEOUS HOUSING AND DRIVE TRAIN	60	25	35	58.3	60	25	35	58.3
	BRAKE DRUMS	20	10	10	50.0	20	10	10	50

SOURCE: Reference 38

TABLE 3-3. ESTIMATED WEIGHT SAVINGS FOR PICKUP TRUCK COMPONENTS

VEHICLE COMPONENT	CONVENTIONAL MATERIAL	SUBSTITUTE MATERIAL	WEIGHT OF CONV. MAT. (POUNDS)	WEIGHT OF SUB. MAT. (POUNDS)	WEIGHT REDUCTION (POUNDS)	% Δ
FRONT BUMPER	STEEL	ALUMINUM	35	25	10	28.6%
REAR STEP BUMPER	STEEL	ALUMINUM	*	*	*	*
SEAT FRAME	STEEL	ALUMINUM	26	11	15	57.7%
RADIATOR SUPPORT	STEEL	ALUMINUM	*	*	*	33.3%
BODY PANEL	STEEL	ALUMINUM	300	150	150	50.0%
CHASSIS COMPONENTS (TRANSMISSION SUPPORTS, CROSS MEMBERS, FRAME RAILS)	STEEL	ALUMINUM	800	400	400	50.0%
FUEL TANK	STEEL	ALUMINUM	*	*	*	66.6%
ENGINE AIR CLEANER	STEEL	ALUMINUM	*	*	*	66.6%

*Data not available

SOURCE: Reference 38

As part of its continuing cost reduction program, the company substitutes plastic material for metal in its automotive safety restraint systems whenever weight reduction can be achieved without compromising structural strength and safety.

The Fibers Division makes STX™ reinforced plastic sheet which is available to other companies for the production of automotive components. Allied claims STX™ weighs between 40 and 60 percent less than steel, but Allied did not specify in which components it may be used. The Fibers Division has also manufactured and sold heat stabilized and blown Capran™ nylon tubing to other companies for use as film in shock absorbers as well as yarn for use in automotive seat belts, carpets, headliners, and tires. Allied believes that the increased use of polyester yarn instead of steel by tire manufacturers in radial applications would decrease tire weight.[39]

3.2.2.2 The Budd Company - The Budd Company states that it has no specific information concerning light truck weight reduction. The company feels that, in general, almost any vehicular component can be made from plastic with an attendant weight saving. However, since Young's modulus is much lower in plastics than in metal, direct substitution of plastic for metal is seldom feasible; differences in shape and section are generally required. Plastic component design should be a function of: (1) the type of plastic, (2) the part characteristics, and (3) the overall design of the vehicle.[40]

3.2.2.3 Libbey-Owens-Ford Company - The company estimates that a "typical" fuel tank made from blow molded high density polyethylene weighs approximately 19.0 pounds which is 7.4 pounds (26.5 percent) lighter than a conventional steel fuel tank (approximately 26.4 pounds).[41]

3.2.2.4 Monsanto - Monsanto Plastics and Resins Company, a divisic of Monsanto, has stated the generic belief that there is an opportunity to reduce the weight of virtually every automobile body and structural component presently being manufactured from metal. However, weight studies for individual components have not been made by Monsanto.

In Table 3-4, Monsanto indicates several applications for plastic being assessed by the automotive industry.

TABLE 3-4. PLASTIC SUBSTITUTION FOR LIGHT TRUCKS

COMPONENT	CONVENTIONAL MATERIAL	SUBSTITUTION MATERIAL
Door Panels	Steel	ABS* or high impact polystyrene
Seat Frame	Steel	ABS*
Valve Cover	Steel	Reinforced nylon
Fan Blade	Steel	Reinforced nylon
Front and Rear Panels	Steel	Reinforced nylon

Quantitative data is not available

Source: Reference 42

*ABS is a family of amorphous thermoplastics. They are produced by combining acrylonitrile, butadiene, and styrene.

Monsanto is involved with weight reduction by the use of "Fome-Cor" laminated panels. "Fome-Cor" is a registered trademark of Monsanto Plastics and Resins Company for polystyrene foam sandwiched between two skins of number forty-two natural craft linerboard. It is used as a substitute for hardboard headlines and door panel substrates. Table 3-5 illustrates some "Fome-Cor" parameters.[42]

3.2.2.5 <u>PPG Industries, Inc.</u> - Light truck components which the Fiber Glass Division of PPA Industries, Inc. believes can be reduced in weight through the use of fiber glass reinforced plastics are displayed in Table 3-6. The following abbreviations are used:

1. SMC: Sheet Molding Compound made from fiber glass reinforced polyester.
2. HMC: High content fiber glass reinforced Molding Compound (a registered trademark of PPG Industries, Inc.)
3. XMC: Directionally reinforced fiber glass Molding Compound (a registered trademark of PPG Industries, Inc.).

TABLE 3-5. HARDBOARD AND "FOME-COR" COMPARISON

PARAMETER	MATERIAL		Δ	%Δ
	HARDBOARD	FOME-COR		
HEADLINER, WEIGHT (LBS)	19.0	8.5	-10.5	-55.3
DOOR PANELS, WEIGHT (LBS)	6.1	2.7	- 3.4	-55.7

Source: Reference 43

TABLE 3-6. PLASTIC COMPONENT SUBSTITUTION

COMPONENET	CONVENTIONAL MATERIAL	SUBSTITUTE MATERIAL
HOOD	STEEL	SMC
RADIATOR SUPPORT	STEEL	HMC
SPARE TIRE CARRIER	STEEL	XMC
REAR STEP BUMPER	STEEL	HMC
LEAF SPRINGS	STEEL	XMC
TAIL GATE	STEEL	SMC
DOOR ASSEMBLY	STEEL	SMC

Source: Reference 43

PPG Industries, Inc. points out that these plastic component substitutions are developmental, and that component design could change dramatically when any one of them reaches full production. Such a design change could affect the magnitude of weight reduction also, weight savings will differ among models and vehicle manufacturers because of part size and design preference. Consequently, accurate projection of potential weight savings is difficult. Generically, the plastic components described in Table 3-6 should represent between 5 and 20 pounds of weight reduction each.[43]

3.2.3 Steel Manfacturers

3.2.3.1 United States Steel Corporation (USS) - Table 3-7 represents USS's estimate of weight reduction potential by using steel products and new design concepts in light trucks. It must be remembered that the following proposals are opportunities in various stages of development and will not become certainties until they are determined to have manufacturing feasibility. The material required for these proposals is available.[44]

TABLE 3-7. MATERIAL SUBSTITUTIONS

VEHICLE SYSTEMS	MATERIAL DESIGN		SAVINGS (LBS)
	EXISTING	PROPOSED	
FRONT AXLE	"I" Section forging	New design tubular steel	20 - 50
FYLWHEEL HOUSING	Steel, iron or aluminum casting	Stamped hot roll steel	10 - 15
BRAKE COMPONENTS	Cast drum and disc	New design stamped steel core rotor	150 - 200
REAR AXLE HOUSING	Various	New design stamped steel	40 - 70

Source: Reference 44

3.2.3.2 Youngstown Steel - Youngstown Sheet and Tube Company, a division of Youngstown Steel, has investigated the utilization of high strength plain carbon and low alloy steels for passenger automobiles. The use of these steels generally involves component redesign. The company feels that component weight savings of

10 - 20 percent can be realized by using lighter gauge materials without loss of strength or durability. Actual weight savings will vary with vehicle size and design.

Youngstown expects the improved steel to be used in body and skin panels, door intrusion beams, bumper reinforcements, and brackets, wheels, and motor mounts.[45]

3.2.3.3 Gulf and Western Manufacturing Company - The General Industrial Group of Gulf and Western Manufacturing produces high strength, low alloy steel front and rear bumpers for light trucks. Table 3-8 provides information for an "average" bumper.[46]

TABLE 3-8. BUMPER COMPARISON

	WEIGHT (POUNDS)	GUAGE (INCHES)
STEEL	26.0	.122
HSLA	19.5	.092
Δ	- 6.5	-.030
%Δ	-25.0	-24.6

Source: Reference 46

3.2.4 Tire and Wheel Manufacturers

3.2.4.1 Firestone Steel Products Company - Firestone Steel Products Company produces an aluminum grille assembly for the Ford Ranger truck. As shown in Table 3-9, the company also manufactures aluminum wheels in sizes 16.0" x 6.0", 16.5" x 6.0", and 19.0" x 6.00" for pickup trucks. These wheels can be used in dual application only. Firestone believes that there is a potential for plastic application, but the weight differential would be insignificant.[47]

3.2.4.2 The General Tire and Rubber Company - The Chemical/Plastics Division of the company is producing the following light truck FRP parts shown in Table 3-10.

TABLE 3-9. ALUMINUM WHEEL SUBSTITUTION

WHEEL SIZE	WEIGHT PER WHEEL (POUNDS)		PERCENT WEIGHT REDUCTION
	LOW CARBON STEEL	ALUMINUM	
16.0" x 6.0"	35	25	29%
16.5" x 6.0"	36	26	28%
19.0" x 6.0"	46	30.3	34%

Source: Reference 48

TABLE 3-10. STEEL AND FRP PART COMPARISON

PART	WEIGHT (POUNDS)		Δ	%Δ
	STEEL	FRP		
HOOD ASSEMBLY	108	75.5	32.5	-30.1
ROOF UNIT	186	130.0	56.0	-30.1
INTERIOR TRIM PANELS	39	27.3	11.7	-30.0

Source: Reference 48

The following assumptions were made in calculating the information in Table 3-10:

a. Weight Ratio: $\frac{FRP_{Weight}}{Steel_{Weight}} = 0.70$

b. Densities: $\frac{FRP_{\rho}}{Steel_{\rho}} = .23$; FRP = $\frac{0.069 \text{ lb}}{\text{in}^3}$,

Steel = $\frac{0.30 \text{ lb}}{\text{in}^3}$

c. Nominal Gauges:

Interior: $\frac{FRP_g}{Steel_g} = 3.04$ (FRP = 0.1000 inches, Steel = 0.0329 inches)

Exterior: $\frac{FRP_g}{Steel_g} = 3.14$ (FRP = 0.1500 inches, Steel = 0.478 inches).

SOURCE: Reference 48

3.2.4.3 The Goodyear Tire and Rubber Company - Although Goodyear manufactures several plastic products, specific weight reduction information is unavailable. The automotive plastic products are:

1. Reinforced fiberglass moldings, which are Sheet Molding Compound (SMC) parts.
2. Injection molded vinyl parts which weigh less than two pounds.
3. Reaction Injection Molded (RIM) exterior front ends.
4. Skin covered soft instrument panels reinforced with rigid metal or plastic and padded with urethane foam.
5. Urethane foam seat cushions.[49]

3.3 DATA FROM AUTOMOTIVE LITERATURE

Automotive manufacturers' projections of vehicle material use, component weight savings, and new production processes are frequently reported by the automotive literature. Under Contract DOT-TSC-1383, with Corporate-Tech Planning, Inc., "Automotive Manufacturing System Assessment," a Materials and Components Reference Book was prepared to track current and future weight reduction strategies as reported in the media. Because of its great volume, data in Materials and Components Reference Book are not reprinted in this report. The Reference Book has been approve for publication. It will be available through the TSC Technical Information Center.

4. SELECTION OF BASELINE VEHICLES

In order to evaluate the near and long term potential of vehicle weight reduction, it is necessary to select vehicles of weight efficient design as baseline vehicles for this exercise. However, the limited availability of detailed vehicle component data posed a great restriction on the selection of the baseline vehicles.

4.1 PASSENGER CARS

As described before, passenger cars can be classified either by their interior volume or by roominess index. The size of passenger cars can also be determined by the number of passengers (including the driver) they are designed to carry. Based on this criteria, passenger cars can be grouped into four-passenger, five-passenger, and six-passenger classes with the four-passenger class represented by mini-compact, subcompact, and compact sized vehicles and five-passenger and six-passenger classes represented by mid- and large-size vehicles, respectively.

4.1.1 Four-Passenger Car

The ideal selection of a baseline vehicle for the four-passenger class would be a European light weight car such as the VW Rabbit. However, detailed component weights for such a vehicle are not available. From the domestic models, the Chrysler Omni was chosen as the baseline vehicle for the four-passenger class. This car was selected for the following reasons:

a. It makes extensive use of high strength steels.[10]

b. It is the first domestic four-passenger car with front-whee drive and a transverse-mounted engine considered to be typical of all four-passenger vehicles in the mid 1980's.

c. Teardown data are available.

The Omni is a four-door hatchback with a 105 CID engine and a manual transmission. Weight breakdowns for the Omni are given in Table 4-1. Detailed weight data for the 1978 Onmi are given in Reference 32.

4.1.2 Five-Passenger Car

A 1978 Ford Fairmont was selected as the baseline vehicle for a five-passenger car. Even though this model was introduced as a replacement for the Maverick, it was a completely new design with emphasis on lightweight and improved fuel efficiency.[11] With a curb weight of 2700 pounds for the base vehicle, the Fairmont is the most weight efficient model among the domestic midsize cars.

The selected model is a four-door sedan with a 140 CID engine and a four-speed manual transmission. Weight breakdowns for this model are given in Table 4-1. Detailed component weights are given in Reference 33.

4.1.3 Six-Passenger Car

The General Motors 1977 B-body cars symbolize the industry's serious effort in vehicle weight reduction. The B-body cars, as represented by the best selling Chevrolet Impala, were made substantially lighter and shorter than the previous models with only small changes in their passenger and luggage room.[12] Ford and Chrysler did not introduce their downsized large size models until the 1979 model year, and reliable detailed weight data for any of these models was not available for this report.

Weight breakdowns for the 1977 Impala are also given in Table 4-1. This vehicle is a four-door sedan with a 305 CID engine and an automatic transmission. The weight data were derived from Reference 12 and from component data provided by the Budd Company.[20]

4.2 LIGHT TRUCKS

The selection of baseline vehicles for light trucks are limited to vehicles of domestic manufacturers. Although some foreign models are comparatively lighter in curb weight, their

TABLE 4-1. WEIGHT BREAKDOWNS FOR IMPALA, FAIRMONT AND OMNI (part 1 of 4)

(ALL WEIGHTS GIVEN IN POUNDS)

	1977 IMPALA	1978 FAIRMONT	1978 OMNI
CURB WEIGHT (WITHOUT FUEL)	3586.0	2699.0	2020.0
BODY AND FRAME	1813.0	1256.5	1090.0
FRONT FENDER OUTER SKIN	24.0	31.0	16.5
FRONT FENDER WHEEL HOUSING	23.0		
FRONT FENDER SUPPORT STRUCTURE	31.0		
HOOD OUTER SKIN	32.5	20.8	17.8
HOOD SUPPORT STRUCTURE	20.0	14.6	10.2
RADIATOR SUPPORT	26.5		
FRONT DOOR OUTER SKIN	24.0	23.5	18.4
FRONT DOOR GUARD BEAM	17.0	12.5	11.3
FRONT DOOR SUPPORT STRUCTURE	39.0	37.0	16.4
REAR DOOR OUTER SKIN	18.0	15.5	13.6
REAR DOOR GUARD BEAM	11.0	7.5	7.0
REAR DOOR SUPPORT STRUCTURE	36.0	31.0	12.5
DECK LID OUTER SKIN	28.5	20.5	
DECK LID SUPPORT STRUCTURE	13.5	13.8	
ROOF OUTER SKIN	35.0		24.2
ROOF SUPPORT STRUCTURE	25.5		7.7
FRAME	261.0		
SILL	55.0		44.2
A POST	45.0		8.4
B POST	25.0		12.9
C POST	18.0		4.6
FLOOR PANEL	106.0		56.8
QUARTER PANEL AND WHEEL WELL	72.0		38.8
TAIL LIGHT PANEL	11.5		
FIREWALL	51.5		
REAR SHELF	17.0		
REAR HATCH BACK			18.4
RADIATOR	15.0	9.8	
FRONT SEAT FRAME	34.5		29.4
FRONT SEAT CUSHION	10.5		9.1
FRONT SEAT BACK	10.5	76.5	5.8
FRONT SEAT TRACK	8.5		9.9
FRONT SEAT MOUNTING	5.0		
REAR SEAT FRAME	9.5		14.1
REAR SEAT CUSHION	10.5	32.8	14.4
REAR SEAT BACK	11.0		8.3

TABLE 4-1. WEIGHT BREAKDOWNS FOR IMPALA, FAIRMONT AND OMNI (part 2 of 4)

(ALL WEIGHTS GIVEN IN POUNDS)

	1977 IMPALA	1978 FAIRMONT	1978 OMNI
ENGINE	576.0	397.6	288.0
ENGINE BLOCK	164.0		71.9
CYLINDER HEAD	86.0	52.8	17.7
AIR CLEANER TOP	2.0		
AIR CLEANER BOTTOM	3.5	4.3	5.4
AIR FILTER ELEMENT	1.0		
STARTER WITH SOLENOID	18.5		12.2
STARTER CONNECTING WIRE	1.0		
FAN BLADE	3.0		.9
FAN PULLY	1.5		3.1
WATER PUMP	14.0	6.8	3.3
FUEL PUMP	1.0	0.8	0.7
OIL PUMP		3.7	2.4
EXHAUST MANIFOLD	31.0	19.8	8.2
EXHAUST MANIFOLD HEAT SHIELD	2.0	1.6	
INTAKE MANIFOLD	41.0	21.0	3.2
VALVE COVER	5.5	3.1	1.9
OIL PAN	6.5	6.1	5.9
BATTERY AND ALTERNATOR	44.0	39.5	39.6
BATTERY	32.0	29.5	26.7
ALTERNATOR	10.0		12.9
ALTERNATOR MOUNTING BRACKET	2.0		
EXHAUST SYSTEM	65.5	50.3	26.4
HEAD PIPE	7.0	4.6	
CATALYTIC CONVERTER	25.5	18.3	9.3
MUFFLER AND PIPE	25.0	20.0	14.3
TAIL PIPE	8.0	4.0	
MOUNTING BRACKETS		3.4	
FUEL SYSTEM	30.5	35.4	18.2
FUEL TANK	28.5	23.4	14.0
FILLER NECK		3.3	1.7
FILLER DOOR		1.2	
GAS LINE		2.5	2.3
CARBON CANISTER		1.6	

TABLE 4-1. WEIGHT BREAKDOWNS FOR IMPALA, FAIRMONT AND OMNI (part 3 of 4)

(ALL WEIGHTS GIVEN IN POUNDS)

	1977 IMPALA	1978 FAIRMONT	1978 OMNI
SUSPENSION	187.0	147.0	144.7
FRONT SPRINGS	25.0	20.0	16.9
FRONT SHOCKS	4.0	5.0	16.5
TIE RODS	6.0		
LOWER CONTROL ARM	34.0	25.5	8.2
UPPER CONTROL ARM	20.0	23.0	
SPINDLE	30.0	21.5	
SWAY BAR	16.0	13.9	10.1
REAR SPRINGS	15.0	14.1	8.7
LOWER ARM	11.0	11.6	16.9
UPPER ARM	6.0	5.7	
REAR SHOCKS	7.0	6.8	5.1
BRAKE	133.5	114.5	76.0
FRONT BRAKE ROTOR	47.0	32.5	14.2
DUST COVER	1.0	1.1	.8
CALIPER	17.0	19.2	
BRAKE PADS	3.0		
BRAKE DRUM	30.0	20.9	21.4
REAR BRAKE BACKING PLATE	19.0	7.4	
REAR BRAKE PARTS		5.7	
MASTER CYLINDER	8.5	6.5	1.3
POWER BOOSTER	8.0		
PARKING BRAKE AND PADLE		16.5	
BRAKE LINE		2.8	
STEERING	51.5	43.0	22.5
STEERING BOX WITH PITMAN ARM	29.5	26.7	
DRAGLINK WITH IDLE ARM	8.5		
POWER PUMP	11.0		
MOUNTING BRACKET	2.5		
STEERING COLUMN AND WHEEL		19.5	10.5
STEERING RACK		21.5	13.3
WHEEL AND TIRES	245.0	193.1	152.3
WHEELS	105.0	85.0	81.3
TIRES	135.0	102.5	69.2
WHEEL COVERS	4.0	4.6	

TABLE 4-1. WEIGHT BREAKDOWNS FOR IMPALA, FAIRMONT AND OMNI (part 4 of 4)

(ALL WEIGHTS GIVEN IN POUNDS)

	1977 IMPALA	1978 FAIRMONT	1978 OMNI
TRANSMISSION	139.5	91.5	80.4
TORQUE CONVERTER WITH FLUID	40.5		
TRANSMISSION PAN	2.5		
TRANSMISSION WITH SHIFT LEVER		65.3	
CLUTCH ASSEMBLY		26.2	
DRIVE AXLE	156.0	150.6	31.9
DRIVE SHAFT	18.0	19.5	
U JOINTS	2.0		
AXLE SHAFT	28.0		
REAR AXLE HOUSING	64.0	131.1	
REAR AXLE GEARING	42.0		
DIFFERENTIAL COVER	2.0		
BUMPERS	144.5	79.0	50.0
FRONT BUMPER FACE	36.5	13.6	8.6
FRONT BUMPER SUPPORT STRUCTURE	23.0	17.0	
FRONT BUMPER ENERGY ABSORBER	14.0	8.4	8.4
REAR BUMPER FACE	33.0	13.0	8.3
REAR BUMPER SUPPORT STRUCTURE	23.9	8.9	
REAR BUMPER ENERGY ABSORBER	14.0	8.4	8.0

load and/or volume capacity are considerably lower. Also, their performance capabilities are considerably below the minimum established standards for domestic models.

The criteria used for selecting the baseline vehicles are, primarily, load and volume efficiencies defined as follows:

$$\text{Load efficiency} = \frac{\text{load capacity}}{\text{curb weight}}$$

$$\text{Volume efficiency} = \frac{\text{volume capacity}}{\text{curb weight}} .$$

4.2.1 Pickup Truck

The basic lowest GVWR pickup models of comparative wheelbase, the Chevrolet C 10, the Dodge D 100, and the Ford F 100, were used for the comparison of load and volume efficiency. These models are generally representative of the comparative efficiency of the designs despite a slight difference in the curb weight to GVWR ratios.

As shown in Table 4-2, volume efficiencies are essentially the same for the three models. However, the Dodge D 100 has substantially higher load capacity and lower curb weight. Therefore, the Dodge D 100 was chosen as the baseline pickup truck. The vehicle selected is equipped with a 225 CID engine, a 3-speed manual transmission, with 3572 pounds actual curb weight. Weight breakdowns of this baseline pickup are shown in Table 4-3.

4.2.2 Van

A comparison of load and volume efficiencies for domestic vans with lowest GVWR is given in Table 4-4. Among these models, the Ford uses separate frame and body while the Chevrolet and the Dodge are both of unitized construction.

The Ford E 100 has the highest load efficiency among the three vans. However, the E 100 is longer and has higher GVWR. Hence, the Dodge B 100 was chosen to be the most efficient model

TABLE 4-2. COMPARISON OF DOMESTIC PICKUP TRUCKS

	CHEVROLET C 10	FORD F 100	DODGE D 100
GVWR (LBS)	4900	4800	5000
WHEELBASE (IN.)	131.5	133.0	131.0
CURB WEIGHT (LBS)	3778	3625	3580
LOAD CAPACITY (LBS)	1122	1175	1420
VOLUME CAPACITY (FT^3)	73.4	73.6	76.6
LOAD EFFICIENCY (LB/LB)	0.30	0.32	0.40
VOLUME EFFICIENCY (FT^3/LB)	0.020	0.020	0.021

Source: Reference 34

TABLE 4-3. WEIGHT BREAKDOWNS FOR BASELINE PICKUP TRUCK AND VAN (part 1 of 4)

(ALL WEIGHTS GIVEN IN POUNDS)

PART	PICKUP D 100	VAN B 100
Curb Weight	3572	3432
Cab (w/o doors, glass, hardware and trim)	258.5	-
Body (w/o doors, glass, hardware and trim)	-	972.5
Cab Door (w/o glass, hardware and trim) (2)	80.0	78.0
Cab Door Glass (2)	16.0	14.0
Cab Door Glass Regulator (2)	8.0	8.0
Cab Door Vent Glass Assembly (2)	10.0	10.0
Cab Rear Window	13.5	-
Windshield	31.0	43.5
Cargo Doors		
Side (2)	-	57.0
Rear (2)	-	50.0
Instrument Panel Assembly	28.0	24.0
Heater Assembly	16.0	19.8
Seat Assembly		
Single	-	25.0
Platform		15.3
3 Passenger Bench	73.0	
Hood	55.0	17.5
Hood Hinge Bracket (2)	10.0	-
Cowl Vent Panel	4.0	4.0
Front Fender (2)	52.0	-

TABLE 4-3. WEIGHT BREAKDOWNS FOR BASELINE PICKUP TRUCK AND VAN (part 2 of 4)
(ALL WEIGHTS GIVEN IN POUNDS)

PART	PICKUP D 100	VAN B 100
Front Fender Inner Wheelhouse (2)	21.0	-
Front Fender Battery Tray	3.0	-
Grille Assembly	5.8	9.0
Grille Lower Panel	4.0	-
Front Structure		
Radiator Support	-	7.5
Radiator & Front Fender Support	40.0	-
Cargo Box	384.0	-
Power Plant Assembly - Complete	674.5	674.5
Engine Assembly - Complete	586.0	586.0
Transmission Assembly - Complete	88.5	88.5
Radiator	14.0	14.0
Prop Shaft	24.0	12.5
Rear Axle Assembly (w/o brakes)	188.8	159.5
Frame (not incl. eng. rear support C/M	350.0	-
Engine Rear Support Crossmember	20.5	5.5
Engine Mounting Brackets (3)	8.5	8.5
Front Suspension Crossmember	-	36.0
Front Susp. Upper Control Arm Assy. (2)	14.5	14.5
Front Susp. Lower Control Arm Assy. (2)	18.0	18.0

TABLE 4-3. WEIGHT BREAKDOWNS FOR BASELINE PICKUP TRUCK AND VAN (part 3 of 4)
(ALL WEIGHTS GIVEN IN POUNDS)

PART	PICKUP D 100	VAN B 100
Front Susp. Lower Control Arm Strut (2)	10.5	13.0
Front Suspension Spring (2)	24.0	23.0
Front Susp. Shock Absorber (2)	4.5	4.5
Rear Suspension Spring (2)	69.0	57.6
Rear Susp. Spring Shackle Assy. (2)	3.0	9.0
Rear Susp. U-bolt Plate (2)	10.0	5.0
Rear Susp. Shock Absorber (2)	7.0	8.5
Steering Gear	15.5	13.5
Steering Gear Arm	2.5	2.5
Steering Knuckle and Arm (2)	31.0	31.0
Steering Linkage Assembly	19.0	36.2
Steering Column and Wheel	24.5	21.2
Wheel Brake - Front (Disc) (2)	36.5	36.5
Wheel Brake - Front Rotor (2)	55.5	55.5
Wheel Brake - Rear (Drum) (2)	22.0	22.0
Wheel Brake - Rear Drum (2)	26.0	26.0
Brake Master Cylinder Assembly	10.2	10.2
Brake Pedal and Shaft	4.0	4.0
Parking Brake Pedal, Brkt. & Frt. Cable	4.0	4.5

TABLE 4-3. WEIGHT BREAKDOWNS FOR BASELINE PICKUP TRUCK AND VAN (part 4 of 4)
(ALL WEIGHTS GIVEN IN POUNDS)

PART	PICKUP D 100	VAN B 100
Road Wheel (5)	107.5	107.5
Tire (5)	130.0	107.5
Exhaust System	37.5	45.0
Fuel Tank	21.0	22.2
Front Bumper		
Face Bar	29.0	28.0
Mounting Bracket (2)	4.0	6.5
Rear Bumper		
Face Bar	61.5*	23.0
Mounting Bracket (2)	-	5.0

*STEP TYPE NOT STANDARD EQUIPMENT

SOURCE: Reference 34

TABLE 4-4. COMPARISON OF DOMESTIC VANS

	CHEVROLET G 10	FORD E 100	DODGE B 100
GVWR (LBS)	4900	5150	4600
WHEELBASE (IN.)	110	124	109
CURB WEIGHT (LBS)	3666	3795	3440
LOAD CAPACITY (LBS)	1234	1355	1160
VOLUME CAPACITY (FT^3)	207.8	206.5	201.5
LOAD EFFICIENCY (LB/LB)	0.34	0.36	0.34
VOLUME EFFICIENCY (FT^3/LB)	0.057	0.054	0.059

Source: Reference 34

and is used as the baseline van. The vehicle selected was equipped with a 318 CID engine, and an automatic transmission, and the actual curb weight is 3432 pounds. Weight breakdown of this vehicle is also given in Table 4-3.

5. METHODOLOGIES

The weight of passenger cars and light trucks can be substantially reduced by vehicle redesign, material substitution, and innovative design for vehicles and components. Vehicle redesign refers to the reduction of vehicle non-functional size (downsizing) and the use of lighter support systems. After vehicle redesign, further reduction in vehicle weight is possible with extensive substitution of high strength or light weight materials for low carbon steel. However, radical reduction in vehicle weight can only be achieved with completely new, innovative vehicle and component designs.

5.1 VEHICLE REDESIGN

Substantial reduction of vehicle weight can be accomplished by total redesign of the vehicle. This involves changes in body dimensions and the conversion to front-wheel drive. At the present, redimensioning refers to vehicle downsizing. By reducing the non-functional size, the exterior dimensions of a vehicle can be reduced while its interior space remains unchanged. Table 5-1 gives a comparison of vehicle parameters for a Ford Thunderbird before and after the redesign.

The selected baseline passenger vehicles, the 1977 Impala, the 1978 Fairmont, and the 1978 Omni, are considered to have completed the redesign process. The Fairmont and the Omni are completely new models designed for dominant low carbon steel utilization.

Front-wheel drive does not necessarily lead to a direct reduction in the weight of the drivetrain. However, front-wheel drive coupled with a transversely mounted engine provides a more efficient and flexible arrangement of underhood space.[13,14] This can result in a shorter front end and, hence, can be translated to weight savings. Table 5-2 compares the dimensions and weights of

TABLE 5-1. A COMPARISON OF VEHICLE PARAMETERS FOR THUNDERBIRD BEFORE AND AFTER REDESIGN

VEHICLE PARAMETER	MODEL YEAR 1979	1980
BODY TYPE	BODY/FRAME	UNITIZED
WHEELBASE (in.)	114.0	108.4
OVERALL LENGTH (in.)	215.5	200.4
HEIGHT (in.)	53.0	53.0
WIDTH (in.)	78.5	74.1
TRACK, FRONT/REAR (in.)	63.2/63.1	58.4/57.2
FRONT HEAD ROOM (in.)	37.3	37.1
FRONT LEG ROOM (in.)	42.2	41.6
FRONT HIP ROOM (in.)	55.6	55.9
REAR HEAD ROOM (in.)	36.2	36.3
REAR LEG ROOM (in.)	32.6	36.4
REAR HIP ROOM (in.)	57.2	52.0
LUGGAGE CAPACITY (cu. ft.)	15.6	18.2
BASE ENGINE (cu. ft.)	302	255
CURB WEIGHT (lbs.)	4028	3275

SOURCE: 1979 and 1980 MVMA Specifications Form

TABLE 5-2. COMPARISON OF X-BODY CARS

VEHICLE PARAMETER	1979	1980
Wheelbase (in.)	111	104.9
Length (in.)	199.6	176.7
Width (in.)	72.9	68.3
Height (in.)	53.2	53.1
Track front/rear (in.)	58.7/57.0	61.9/59.6
Weight (lbs)	3262	2505
Base Engine	250 cu.-in. six	151 cu.-in. four
Optional Engine	305 cu.-in. V8	173 cu.-in. V6
Trunk Space (cu.-ft.)	12.6 4-door	12.5 notchback
		20.1 hatchback

Source: 1979 and 1980 MVMA Specifications Form a GM newly redesigned front-wheel drive X-body car to its rear-wheel drive predecessor. Wide-spread use of front-wheel drive in small and midsize cars is expected in the mid-1980's.

The difference between vehicle actual size and functional size is much smaller for light trucks than for passenger cars. Therefore, the potential magnitude of weight reduction by down-sizing is significantly less for light trucks than for passenger cars. A size reduction for light trucks may not be functionally feasible because of the requirements for load area and passenger carrying capacity.

Front-wheel drive presents both a benefit and a problem for light trucks. The benefit is that the difference in wheel traction on a leveled road between empty and full-load can be minimized. However, during up-hill driving conditions, under a full-load, a front-wheel drive truck with a conventional long rear overhang may experience inadequate traction. A long wheel-base with short rear overhang will have an adverse effect on vehicle weight.

5.2 MATERIAL SUBSTITUTION

Material substitution is an important approach for achieving vehicle weight reduction. It involves mainly the replacement of a production heavy metal component with one differing only in material and gauge.

There are many materials which have great weight saving potential. For example, magnesium is 4.5 and 1.5 times lighter than cast iron and aluminum, respectively, and has comparable strength and ductility to aluminum in the commonly used die cast form. It is abundant in the earth crust, and is available domestically in unlimited quantities from seawater, brine, and various ores. It has been used in foreign automobiles such as the VW Bug, Fiat Dino, and Porsche 911 and 917 models. It is not used in significant quantities in domestic automobiles because of high cost, limited availability, and difficult fabrication techniques.

In this document, the selection of the substitution materials is necessarily limited to those that are reasonably low cost and can be adapted to present facilities without immense capital investment. Under these limitations, high strength steel, aluminum, and plastic become the most prominent choices.

5.2.1 Substitutional Materials Considered

The substitutional materials to be considered in this document include high strength steels (HSS), aluminum alloys, fiberglass reinforced plastic (FRP), and hybrid reinforced plastic (HRP).

Because of their exceptional strength, high strength steels have started to replace low carbon steels for body panels and structural components. For certain applications, attempts are being made to substitute them for cast iron. Many components can be designed more effectively by using high strength steel at reduced thicknesses.

The family of high strength steels includes carbon and low alloy (HSLA) steels. The yield strength of these sheet steels ranges from 33 to 80 ksi. These steels offer many of the same advantages of the low carbon steels and are completely compatible with existing manufacturing equipment. They can be formed, joined, and painted at the high production rates used in the automotive industry.

The use of aluminum in automobiles can represent significant weight reduction. On an equal volume basis, aluminum weighs 1/3 as much as steel. In addition to its light weight, the advantages of aluminum for automotive applications include the ability to be easily cast, drawn, extruded, or machined, and a high resistance to environmental corrosion.

In the past, aluminum was mainly used in castings. However, since new aluminum alloys with good strength and dent resistance were developed, more and more aluminum has been used in body panels and structural components. For 1979 model year passenger cars, approximately 60 percent of the aluminum utilized is in the form of castings. The remaining 40 percent is generally found in extruded, roll formed, or stamped components.[15] A summary of aluminum components on 1979 passenger cars produced domestically is given in Table 5-3. Many applications now existing for passenger cars can be readily transferred to light trucks. Table 5-4 shows the potential aluminum applications in future passenger cars and light trucks.

Advanced composite materials, originally developed for the aerospace industry, offer greater weight reduction potential in automotive applications than can be achieved with traditional materials. These composite materials combine high strength and stiffness with good fatigue and corrosion resistance. They also offer excellent design flexibility.

Two composite materials will be considered in this document: fiber glass-reinforced plastic (FRP) and hybrid reinforced plastic (HRP). FRP exterior components already have been used as lightweight substitutes for steel. It should be pointed out that FRP replaces the function of the steel, not the design. In many instances, a component using FRP is a completely new design; hence, an exact weight comparison with FRP and steel cannot be accomplished. For example, the 1973 Chrysler Newport had a single 12-pound FRP panel which replaced a three component front end weighing a total of 22 pounds. For GMC medium duty trucks, a 16 component steel tilt front end weighing a total of 257 pounds was replaced with an FRP three component redesign weighing only 98 pounds.[16]

TABLE 5-3. SUMMARY OF ALUMINUM COMPONENTS ON 1979 DOMESTIC PASSENGER AUTOMOBILES (part 1 of 3)

BODY

- Deck Lid (Inner and Outer)
- Deck Lid Guards
- Hoods (Inner and Outer)
- Hood Hinges
- Arm Rest Frames
- Dash Panel Insert
- Head Rest Bar
- Seat Backs
- Seat-Power Adjuster Assembly
- Tulip Panel
- Sun Roof Hatch Frame and Panel
- Carpet Scuff Plate
- Door Guards
- Door Lock Spacers
- Instrument Panel Tie Bar
- Luggage Rack and Air Deflector
- Load Floor
- License Plate Bracket
- Flipper Panel

BUMPER SYSTEMS

- Bumper Face Bars, Extruded, Anodized
- Bumper Face Bars, Sheet, Chrome Plated
- Bumper Face Bars, Extruded, Chrome Plated
- Reinforcements and Brackets

WHEELS

- Cast Wheels
- Forged Wheels
- Stamped Wheels
- Hub Caps
- Trim Rings
- Wheel Covers

BRAKES

- Drums
- Master Cylinder
- Proportioning Valve
- Splash Shield
- Silencer Pads

TABLE 5-3. SUMMARY OF ALUMINUM COMPONENTS ON 1979 DOMESTIC PASSENGER AUTOMOBILES (part 2 of 3)

TRIM MOULDINGS

Body, Roof, Window, Windshield, Fender, Door
Dashboard, Lights, Grille, Rocker Panel
Door Belt Trim

MOTOR - POWER TRAIN & ACCESSORIES

Engine Head
Intake Manifolds
Cam Shaft Housing
Charcoal Cannister Tray
Power Steering Pump Housing
Alternator Bracket
Radiator
Radiator Support Assembly
Oil Filter Cap
Oil Filter Base
Pump Mounting Brackets
Rear Cover Plate
Air Cleaner Housing
Heat Shields
Fuel Filler Tube
Gearbox Case
Steering Gear Housing
Transmission Housing (Automatic)
Transmission Bearing Retainer
Fuel Pump
Water Pump
Water Outlets
Fan Blades
Air Conditioning
Transmission Housing Dust Cover

MISCELLANEOUS ENGINE COMPONENTS

Fan Spacer
Distributor Body
Alternator Housing
Oil Pump
Fuel Injectors
Front Wiring Harness
Engine Temperature Sensors
Air Pump Housing
Pistons
Timing Chain Cover

TABLE 5-3. SUMMARY OF ALUMINUM COMPONENTS ON 1979 DOMESTIC PASSENGER AUTOMOBILES (part 3 of 3)

MISCELLANEOUS FASTENER & SCREW MACHINE/UPSET PARTS

Drive Pinion Gear for Power Door Lock
Seat Belt Actuator Pins
Distributor Cap Inserts
Windshield Wiper Bolt
Ignition Coil Insert
Headlamp Adjusting Screws
Brake Valve Parts
Ashtray Rivets
Stator Rivets

Source: Reference 15.

TABLE 5-4 POTENTIAL ALUMINUM APPLICATIONS IN FUTURE PASSENGER AUTOMOBILES AND LIGHT TRUCKS

PASSENGER CARS

Fenders
Doors
Roof Bows
Steering Bracket
Fuel Tank
Door Beams
Valve Covers
Air Conditioner Bracket
Engine Mounts
Transmission Oil Pan
Battery Tray
Engine Oil Pan
Differential Cover Plate
Heater Core
Quarter Panel
Roof
Floor Pan
Chassis
Drive Shaft
Aperture Panels

LIGHT TRUCKS

Roof
Roof Bows
Panels
Doors
Chassis
Step Bumper
Cargo Box

SOURCE: Reference 15

The HRP considered have two graphite epoxy face sheets and a fiberglass epoxy core. Hybridization in this manner results in a composite that has significantly improved flexural properties at significantly less cost than an all graphite composite. The hybrid composites that contain 20 percent graphite and 80 percent glass can be two to seven times as stiff as an all glass composite.[17]

Mechanical properties of the hybrid composite depend on the fiber length and the relative orientation of the fibers. In a unidirectional arrangement, all the fibers are parallel to each other, and are aligned in the direction of the stress. In a quasi-isentropic arrangement, the composite consists of alternate layers of parallel fibers that are arranged sequentially at relative angles of 45°. Chopped fibers can be randomly oriented in three dimensions. Two types of fiber lay-up are selected here: the quasi-isotropic graphite fiber/random chopped E glass fiber to be used for panel members and solid sections, and the unidirectiona graphite fiber/random chopped E glass fiber to be used for thin-walled beam members.

Densities and modulus of elasticity of the selected substitutional materials as well as those of low carbon steel are given in Table 5-5.

5.2.2 Design Criteria

Functional requirements demand that vehicle component members meet static and dynamic load design criteria. Static load design criteria control the rigidity and/or strength of a specific component member or of the entire vehicle structure. The dynamic load design criteria require that the entire vehicle and specific component members satisfy the strength, dynamic response, and durability requirements.

Besides the static and dynamic load design criteria, there are crashworthiness load design criteria which are derived from requirements concerning front barrier impact, rollover, side door penetration, fuel tank integrity, etc. Because the relationship

TABLE 5-5 PROPERTIES OF SUBSTITUTING MATERIALS

MATERIAL	DENSITY (g/cm^3)	MODULUS (GPa)
Low Carbon Steel	7.83	207
HSS	7.83	207
Aluminum	2.70	72
FRP	1.80	18
HRP		
Quasi-isotropic HM graphite fiber/random chopped E glass fiber	1.76	43
Unidirectional HM graphite fiber/random chopped E glass fiber	1.76	116

Source: Reference 17

between various deformation modes and occupant protection is not fully understood, and design guidelines are not completely established, crash requirements will not be discussed.

From a conventional structural viewpoint, there are three types of design requirements: stiffness, strength, and vibration. The stiffness and the strength requirements govern, respectively, the maximum allowable deflection and the maximum allowable stress of a structure under a specified load. The vibration design requirement controls the desired frequency and mode response. These structural design requirements and the related design constraints are discussed in detail by Chang and Justusson.[18]

The components made of substitutional material are acceptable only if the corresponding structural responses are equal to or better than those of the original design. In this document, the substitutional component is assumed to have the same overall dimensions and geometry as the original one except for possible changes in thickness.

Because of the large number of vehicle components involved, it is necessary to establish a simplified approach to calculate weight savings by material substitution. For this reason, vehicle components were classified according to their geometrical shapes into three groups: panels, thin-walled beams, and solid sections. Panel members (e.g., hood, roof panel, and door panels) and thin-walled beam members (e.g., chassis frame, pillars, and rocker panel are made of sheet stock and account for most of the vehicle structural weight. Solid section members (e.g., various reinforcement brackets, hinges, and the hood latch support) are used mainly as reinforcements and linkages. They contribute comparatively little weight to the vehicle structure.

By considering similar geometries for equivalent structures, the functional relationship between the structural criteria and the corresponding design variables can be simplified by eliminating many complicated geometric factors. Hence, design parameters can be reduced to a function of basic material properties: modulus of elasticity (E), Poisson's ratio (ν), yield strength (σ_y), density (ρ), and the wall thickness (t). Equations involving these parameters are given in Tables 5-6 to 5-8 for the various geometries which are considered.

Chang and Justusson found that for direct material substitution, stiffness is the most restrictive structural requirement of the total vehicle and its components. Using stiffness as the design criterion, the weight of a replacement component can be determined from the following formula:

$$W_n = W_o \left(\frac{\rho_n}{\rho_o}\right) \left(\frac{Eo}{En}\right)^{\frac{1}{m}} \qquad \text{(eq. 5-1)}$$

where:

W is the weight of the component

ρ is the density of the material

E is the modulus of elasticity of the material

n and o refer to new material and original material

m = 1 for thin-wall beams

m = 2 for body panels

m = 3 for solid sections.

5.2.3 Results

Four cases of material substitution for weight reduction were considered: the HSS dominant case, the FRP dominant case, the aluminum dominant case, and the HRP dominant case. These cases represent different levels of material substitution technology. The materials used for various components in each case are listed in Table 5-9. In all four cases, the vehicles were assumed to have aluminum cylinder heads, stainless steel exhaust manifolds,[19] HRP springs, foam or aluminum bumpers,[20] and a high density polyethylene (HDPE) fuel tank.

By applying the formula for equal stiffness and using the material properties listed in Table 5-5, weight savings that can be achieved with the substitutional materials were computed. Table 5-10 lists the weight savings for components of various geometrical shapes. Weight savings by HSS substitution is the result of gauge

TABLE 5-6 COMPARISON OF REQUIRED STRUCTURAL CHARACTERISTICS FOR PANEL MEMBERS -- DIRECT SUBSTITUTION OF MATERIAL --

Structural Characteristic	Ratio of Structural Characteristics*	Thickness Ratio Required for Equal Structural Characteristics
Stiffness, S (Oil Canning Resistance)	$\frac{S_n}{S_o} = \frac{E_n}{E_o}\left(\frac{t_n}{t_o}\right)^2$	$\frac{t_n}{t_o} = \left(\frac{E_o}{E_n}\right)^{\frac{1}{2}}$
Denting Resistance, D	$\frac{D_n}{D_o} = \left(\frac{\sigma_{yn}(\dot{\varepsilon})t_n^2}{\sigma_{yo}(\dot{\varepsilon})t_o^2}\right)^2 \frac{S_o}{S_n}$	$\frac{t_n}{t_o} = \frac{\sigma_{yo}(\dot{\varepsilon})}{\sigma_{yn}(\dot{\varepsilon})}\left(\frac{E_n}{E_o}\right)^{\frac{1}{2}}$
Buckling Resistance, B	$\frac{B_n}{B_o} = \frac{E_n}{E_o}\frac{1-\nu_o^2}{1-\nu_n^2}\left(\frac{t_n}{t_o}\right)^3$	$\frac{t_n}{t_o} = \left(\frac{1-\nu_o^2}{1-\nu_n^2}\frac{E_o}{E_n}\right)^{\frac{1}{3}}$
Stress Yield Factor, Y	$\frac{Y_n}{Y_o} = \frac{\sigma_{yn}(\dot{\varepsilon})}{\sigma_{yo}(\dot{\varepsilon})}\frac{E_o}{E_n}\frac{\bar{S}_n}{\bar{S}_o}$	$\frac{\bar{S}_n}{\bar{S}_o} = \frac{E_n}{E_o}\frac{\sigma_{yo}(\dot{\varepsilon})}{\sigma_{yn}(\dot{\varepsilon})}$
Vibration Frequency, F	$\frac{F_n}{F_o} = \left(\frac{E_n}{E_o}\frac{t_n}{t_o}\frac{\rho_o}{\rho_n}\right)^{\frac{1}{2}}$	$\frac{t_n}{t_o} = \frac{E_o}{E_n}\frac{\rho_n}{\rho_o}$

*Subscripts n and o refer to new material and original material.

SOURCE: Reference 18

TABLE 5-7. COMPARISON OF REQUIRED STRUCTURAL CHARACTERISTICS FOR THIN-WALLED BEAM MEMBERS --DIRECT SUBSTITUTION OF MATERIALS--

Structural Characteristic	Ratio of Structural Characteristics*	Thickness Ratio Required for Equal Structural Characteristics
Bending Stiffness, S^b	$\frac{S_n^b}{S_o^b} = \frac{E_n}{E_o}\frac{t_n}{t_o}$	$\frac{t_n}{t_o} = \frac{E_o}{E_n}$
Torsional Stiffness, S^t	$\frac{S_n^t}{S_o^t} = \frac{G_n}{G_o}\frac{t_n}{t_o}$ (closed section)	$\frac{t_n}{t_o} = \frac{G_o}{G_n}$
	$= \frac{E_n}{E_o}\frac{t_n}{t_o}$ (open section)	$\frac{t_n}{t_o} = \frac{E_o}{E_n}$
Buckling Resistance, B	$\frac{B_n}{B_o} = \frac{E_n}{E_o}\frac{t_n}{t_o}$	$\frac{t_n}{t_o} = \frac{E_n}{E_o}$
Local Buckling Resistance, L	$\frac{L_n}{L_o} = \frac{E_n}{E_o}\frac{1-\nu_o^2}{1-\nu_n^2}\left(\frac{t_n}{t_o}\right)^3$	$\frac{t_n}{t_o} = \left(\frac{1-\nu_n^2}{1-\nu_o^2}\frac{E_o}{E_n}\right)^{\frac{1}{3}}$
Crippling Resistance, C	$\frac{C_n}{C_o} = \left(\frac{E_n}{E_o}\frac{\sigma_{yn}}{\sigma_{yo}}\right)^{\frac{1}{2}}\left(\frac{t_n}{t_o}\right)^{1.75}$	$\frac{t_n}{t_o} = \left(\frac{E_o}{E_n}\frac{\sigma_{yo}}{\sigma_{yn}}\right)^{\frac{1}{3.5}}$
Stress Yield Factor, Y	$\frac{Y_n}{Y_o} = \frac{\sigma_{yn}(\dot{\varepsilon})}{\sigma_{yo}(\dot{\varepsilon})}\frac{E_o}{E_n}\frac{S_n}{S_o}$	$\frac{S_n}{S_o} = \frac{E_n}{E_o}\frac{\sigma_{yo}(\dot{\varepsilon})}{\sigma_{yn}(\dot{\varepsilon})}$
Vibration Frequency, F	$\frac{F_n}{F_o} = \left(\frac{E_n}{E_n}\frac{\rho_o}{\rho_n}\right)^{\frac{1}{2}}$	—

*Subscripts n and o refer to new material and original material.

SOURCE: Reference 18

TABLE 5-8. COMPARISON OF REQUIRED STRUCTURAL CHARACTERISTICS FOR SOLID SECTIONS --DIRECT SUBSTITUTION OF MATERIAL--

STRUCTURAL CHARACTERISTICS	RATIO OF STRUCTURAL CHARACTERISTICS*	THICKNESS RATIO REQUIRED FOR EQUAL STRUCTURAL CHARACTERISTICS
Equal Bending Stiffness	$\frac{Sn}{So} = \frac{En}{Eo}\left(\frac{tn}{to}\right)^3$	$\frac{tn}{to} = \left(\frac{Eo}{En}\right)^{1/3}$
Equal Bending Moment Resistance	$\frac{Mn}{Mo} = \frac{\sigma n}{\sigma o}\left(\frac{tn}{to}\right)^2$	$\frac{tn}{to} = \left(\frac{\sigma o}{\sigma n}\right)^{1/2}$
Equal Bending Moment Resistance in Fatigue	$\frac{M^F n}{M^F o} = \frac{\sigma n^F}{\sigma o^F}\left(\frac{tn}{to}\right)^2$	$\frac{tn}{to} = \left(\frac{\sigma o^F}{\sigma n^F}\right)^{1/2}$

* Subscripts n and o refer to new material and original material

SOURCE: Reference 17

TABLE 5-9. MATERIALS USED FOR VARIOUS VEHICLE COMPONENTS FOR THE CASES CONSIDERED

VEHICLE COMPONENT	HSS DOMINANT CASE	FRP DOMINANT CASE	ALUMINUM DOMINANT CASE	HRP DOMINANT CASE
Body Panels	HSS	FRP	Aluminum	HRP
Structural Parts	HSS	HSS	HSS	HRP
Engine Block	Cast Iron	Cast Iron	Aluminum	Aluminum
Wheels	Aluminum	HRP	Aluminum	HRP

TABLE 5-10. WEIGHT SAVINGS FOR COMPONENTS OF VARIOUS GEOMETRICAL SHAPES

GEOMETRICAL SHAPE	PERCENT OF WEIGHT SAVINGS			
	HSS	ALUMINUM	FRP	HRP
Panel	17	42	22	50
Thin-Walled Beam	20	0	0	60
Solid Section	20	50	48	60

reduction. Average weight reduction with HSS is reported to vary from 15 to 30 percent, depending upon the individual parts.[10] Higher strength steel has higher dynamic stiffness; hence, it can be used advantageously in stiffness controlled structures to achieve greater weight reduction.[21]

Applying the percent of weight savings listed in Table 5-10, weights for replacement components were computed for all four cases of the three baseline passenger vehicles and three baseline light trucks, as shown in Appendices A and B, respectively. Tables 5-11 through 5-13 summarize the resultant curb weights and the percent distribution of materials for the passenger vehicles. Table 5-14 summarizes the resultant curb weights for the baseline light trucks. Since the original weights of materials of these trucks are not available, distribution of materials for light trucks cannot be determined at this time.

Curb weights shown in Tables 5-11 through 5-14 are the results of direct material substitution. Secondary weight savings have not been taken into account. No attempt is made at this time to evaluate the costs of these substitutions. The cases shown are hypothetical; no vehicle will be made with one dominant substituting material. The selection of substituting material for each component should be determined by optimizing the manufacturing cost and weight of the total vehicle. A study to determine the relationship between vehicle weight and cost will be conducted. The results of this study will be reported in the 1980 Summary Source Document.

5.4 PROPAGATED WEIGHT REDUCTION

Reduction in vehicular upper body weight allows reduction in under body weight, which leads to reduction in the weight of chassis components. As the result of this weight interaction, for every pound of primary weight reduction, there is a secondary weight change. This secondary weight reduction ranges from the rather conservative estimate of 0.4 pound to a significant appraisal of 1.6 pounds per pound of primary weight change.[22-25] A brief presentation of various methodologies for deriving the weight propagation factors is presented in the following subsections.

TABLE 5-11. PERCENT DISTRIBUTION OF MATERIAL FOR 4-PAX BASELINE VEHICLE

MATERIAL	CASE				
	ORIGINAL	HSS	FRP	ALUMINUM	HRP
Steel	54.0	18.7	18.9	20.1	22.8
HSS	8.1	37.3	20.6	21.8	0.6
Cast Iron	9.6	8.3	8.4	4.7	5.4
Aluminum	2.8	6.3	4.1	21.8	6.4
Copper/Brass	1.0	1.2	1.2	1.2	1.4
Lead	1.2	1.4	1.4	1.5	1.7
Zinc	0.6	0.7	0.7	0.7	0.8
Glass	3.5	3.8	3.9	4.2	4.8
Rubber	5.5	6.1	6.2	6.6	7.6
NRP	4.0	4.4	4.5	4.8	5.5
FRP	0	0.5	16.8	0.5	0.6
HRP	0	0.6	2.4	0.6	29.1
Other	9.7	10.7	10.9	11.5	13.3
Curb Weight Less Fuel (lbs.)	2020	1821	1794	1691	1467

TABLE 5-12. PERCENT DISTRIBUTION OF MATERIAL FOR 5-PAX BASELINE VEHICLE

MATERIAL	CASE				
	ORIGINAL	HSS	FRP	ALUMINUM	HRP
Steel	57.9	20.0	20.2	21.0	24.8
HSS	5.1	36.9	28.8	29.9	0.4
Cast Iron	14.8	10.3	10.4	6.4	7.6
Aluminum	4.2	8.8	6.8	17.6	11.1
Copper/Brass	0.9	0.5	0.5	0.5	0.6
Lead	0.7	0.8	0.8	0.8	1.0
Zinc	0.5	0.5	0.6	0.6	0.7
Glass	2.9	3.4	3.4	3.5	4.2
Rubber	4.4	5.2	5.2	5.4	6.5
NRP	5.5	6.4	6.4	6.7	8.0
FRP	0	0.6	8.7	0.7	0.8
HRP	0	0.9	2.5	1.0	27.2
Other	3.1	5.7	5.7	5.9	7.1
Curb Weight Less Fuel (lbs.)	2699	2322	2301	2214	1856

TABLE 5-13. PERCENT DISTRIBUTION OF MATERIAL FOR 6-PAX BASELINE VEHICLE

	CASE				
MATERIAL	ORIGINAL	HSS	FRP	ALUMINUM	HRP
Steel	64.5	22.2	22.5	24.1	27.1
HSS	0	36.5	19.0	20.4	0
Cast Iron	16.9	11.9	12.1	7.3	8.3
Aluminum	2.9	8.3	6.6	25.4	11.4
Copper/Brass	0.8	0.4	0.4	0.4	0.5
Lead	0.5	0.6	0.6	0.6	0.7
Zinc	0.4	0.4	0.5	0.5	0.6
Glass	2.5	3.0	3.0	3.2	3.7
Rubber	2.6	3.1	3.2	3.4	3.9
NRP	4.8	5.7	5.8	6.2	7.1
FRP	0	0.6	17.5	0.6	0.7
HRP	0	0.8	2.2	0.8	27.9
Other	4.1	6.5	6.6	7.1	8.1
Curb Weight Less Fuel (lbs.)	3598	3022	2979	2781	2429

TABLE 5-14. CURB WEIGHT FOR LIGHT TRUCKS

TYPE OF TRUCK	CURB WEIGHT (LB)				
	ORIGINAL	HSS DOMINANT	FRP DOMINANT	ALUMINUM DOMINANT	HRP DOMINANT
PICKUP TRUCK (D 100)	3572	3029	2981	2775	2456
VAN (B 100)	3432	2860	2813	2606	2293
UTILITY VEHICLE (RAMCHARGER)	4277	3709	3668	3394	3216

5.4.1 Chrysler's Methodology

Chrysler proposes an interacting weight model to determine weight-weight interaction.[22,23] A vehicle is divided into twelve groups: an upper body group, an under body group, and ten major chassis groups. The upper body group consists of the major body panels, interior upper body structure, the dash, the seats, the glass, and the interior and exterior trim. The under body group consists of the floor pan, rails, and side sills. The chassis groups are made up of the bumpers and those components that either propel, stop, or suspend the vehicle. The upper body components are considered non-interacting, while the under body and chassis components are interacting as shown in Figure 5-1.

The relationships between component groups and total vehicle weight are obtained with regression analysis for five major car lines. The simple power curve in the form of:

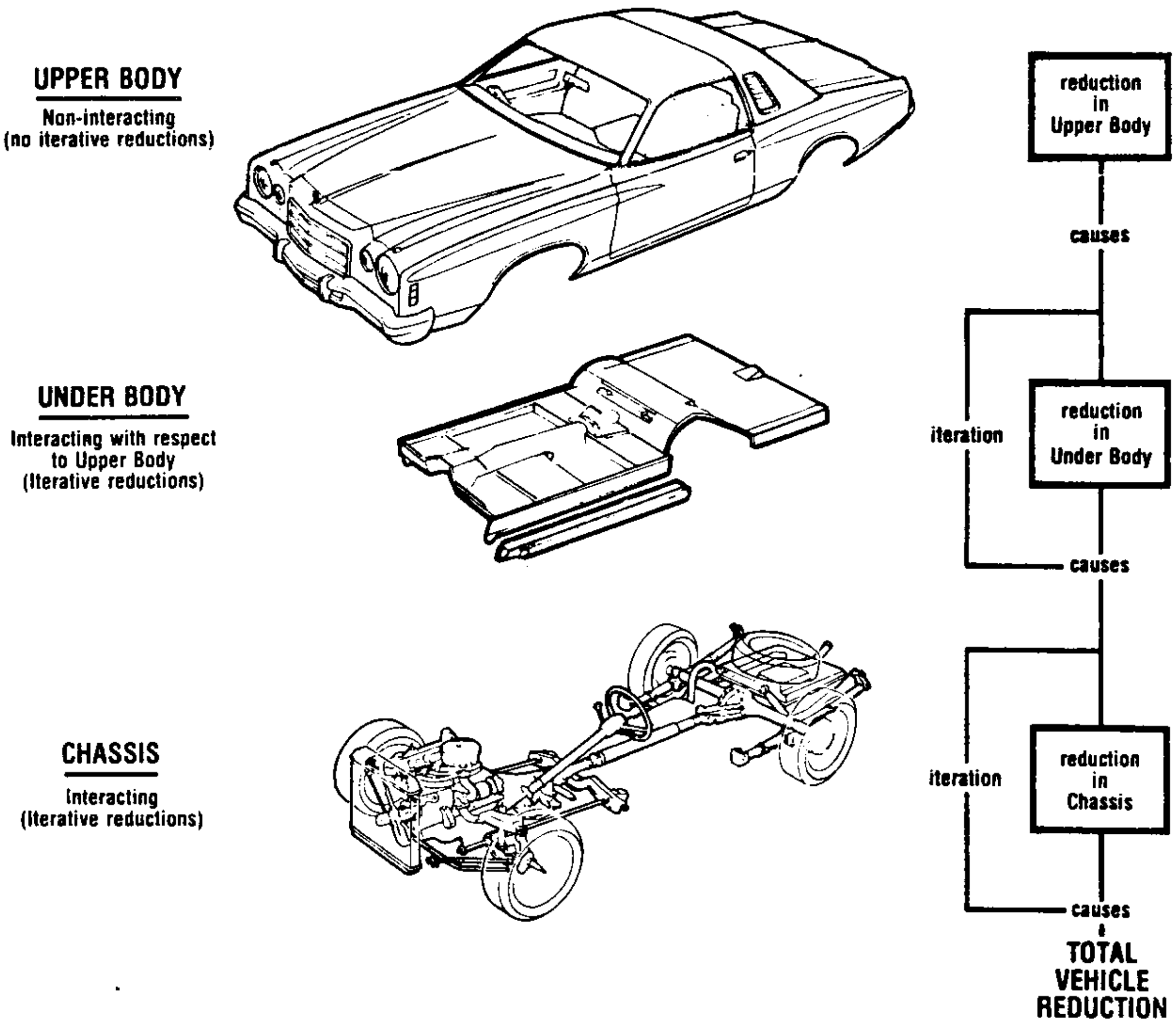
$$y = a\ X^b \qquad \text{(eq. 5-2)}$$

is used for the regression analysis. The five car lines used to obtain a and b are 1976 four-door models with automatic transmissions and unit body construction. The resulting relationships are given in Table 5-15.

A computer program is used to solve the 12 equations simultaneously. The results show that for an intermediate size vehicle, such as the Charger SE, a 200 pound reduction in upper and under body groups can lead to an iterative chassis weight savings of 221 pounds. Thus, for a primary weight reduction of 200 pounds, total vehicle weight savings is 421 pounds, or a weight propagation factor of 2.11.

5.4.2 Ford's Methodology

Ford divides the vehicle components into two groups: product function weight, and dependent weight.[24] The product function weight is defined as a function of vehicle packaging and configuration. It is determined by the type of product one desires as well



Source: Reference 23.

FIGURE 5-1. CHRYSLER'S INTERACTING WEIGHT MODEL

TABLE 5-15. VEHICLE WEIGHT-WEIGHT RELATIONSHIPS ($Y = aX^b$) (1976 DATA BASED ON VL, HN, RW, P & C*)

VEHICLE COMPONENT GROUP	CONSTANT a	CONSTANT b	CORRELATION COEFFICIENT
Chassis Groups			
Power Plant	3.702	0.65	0.91
Final Drive	0.545	0.69	0.84
Forestructure	0.002	1.34	0.83
Suspension	0.014	1.18	0.91
Steering	$6x10^{-4}$	1.39	0.97
Brakes	0.032	1.04	0.99
Wheels & Tires	0.005	1.29	0.99
Exhaust	$5x10^{-6}$	1.97	0.97
Fuel System	0.057	0.74	0.96
Bumpers	0.183	0.84	0.88
Body Groups			
Under Body	0.023	1.11	0.95
Upper Body	0.004	1.54	0.98

*Vehicle Designation

VL - Valiant, Dart
HN - Volare, Aspen
RW - Fury, Coronet
P - Gran Fury
C - Chrysler

Source: Reference 23

as the materials and design used in achieving this aim. The dependent weight is defined as a function of total vehicle weight; thus, it is affected by weight decisions made elsewhere. Therefore, total vehicle weight can be expressed as:

$$W_{TOT} = W_{PF} + W_{DEP}. \qquad \text{(eq. 5-3)}$$

The dependent weight consists of the weight of ten subsystems: engine, transmission and clutch, driveline, fuel system, exhaust, bumpers, brakes, wheels and tires, steering and suspension, and frame. The dependence of each subsystem weight on total vehicle weight (curb weight, inertia weight or gross vehicle weight) is determined by regression analysis. The following three different regression equations are used:

$$W_{SUB} = A\ W_{TOT}\ . \qquad \text{(eq. 5-4)}$$

$$W_{SUB} = B + C\ W_{TOT}\ . \qquad \text{(eq. 5-5)}$$

$$W_{SUB} = D\ W_{TOT}^{E}\ . \qquad \text{(eq. 5-6)}$$

Ford found that the linear equation (eq. 5-5) generally gave higher correlation coefficients than the other two equations, and that inertia weight gave the highest degree of correlation when used as total vehicle weight. Weight data from twelve 1975 Ford production cars and from four 1975 Chrysler models were used to derive the functional dependence of the ten subsystem weights on total vehicle weight. Table 5-16 shows the results based on vehicle inertia weight.

By adding all the derived constants shown in Table 5-16, the dependent weight function becomes:

$$W_{DEP} = -115.8 + .574\ W_I\ . \qquad \text{(eq. 5-7)}$$

When this equation is substituted into eq. 5-3, one obtains

$$W_I = 2.34\ W_{PF} - 271.8\ ,$$

TABLE 5-16. FUNCTIONAL DEPENDENCE OF SUBSYSTEM WEIGHTS ON VEHICLE INERTIA WEIGHT ($W_{SUB} = B + CW_I$)

SUBSYSTEM	B	C	CORRELATION COEFFICIENT
Engine	-57.1	.161	.985
Transmission	-26.1	.043	.947
Driveline	11.9	.034	.983
Fuel System	46.5	.025	.830
Exhaust	6.0	.011	.914
Bumpers	-24.1	.053	.985
Brakes	1.2	.041	.996
Wheels and Tires	16.1	.052	.974
Steering	-30.5	.025	.967
Suspension, Frame	-60.0	.129	.977

and, consequently

$$\frac{dW_I}{dW_{PF}} = 2.34 \quad .$$

This means that for every pound change in product function weight, the total vehicle weight (in this case, the vehicle inertia weight) changes by 2.34 pounds. Of this total weight change, 1.34 pounds (secondary factor) came from the dependent subsystems. The secondary weight factors for all cases as derived by Ford are summarized in Table 5-17.

The derived secondary weight factors only apply to weight changes in product function weight. For initial weight changes in a dependent subsystem, Ford states that it is necessary to modify that subsystem relationship and claims that the secondary weight factor would be slightly reduced.

5.4.3 GM's Methodology

GM derives the subsystem weight compounding factors by grouping vehicle component weights into functional subsystems.[25] Not all functional subsystems are considered to be affected by a change in vehicular weight. Table 5-18 shows functional subsystems which are affected by a change in vehicular weight. Only homogeneous families of vehicles, either all transverse front-wheel drive vehicles or all rear-wheel drive vehicles, should be used for the analysis. Also, the vehicles used should comply with the same regulations.

Once teardown weights of subsystems for a group of vehicles are obtained, linear equations with gross vehicle weight (GVW) as the independent variable can be produced from a least squares fit of the weight data. The slope of the line is defined as the subsystem weight influence coefficient (WICS), while the sum of these coefficients is defined as the vehicle weight influence coefficient (WICV).

TABLE 5-17. SECONDARY WEIGHT FACTORS

ASSUMED TOTAL WEIGHT PARAMETER AND FORM OF FUNCTIONAL REPRESENTATION	2500 LB CAR		5000 LB CAR	
	$\Sigma \frac{dW_{SUB}}{dW_{TOT}}$	SECONDARY WT. FACTOR LBS/LB	$\Sigma \frac{dW_{SUB}}{dW_{TOT}}$	SECONDARY WT. FACTOR LBS/LB
1. Linear Eq. 5-5 with Inertia Weight	.574	1.34	.574	1.34
2. Highest Correlation Coefficient in each case	.578	1.37	.581	1.39
3. Eq. 5-5 with Curb Weight	.553	1.23	.553	1.23
4. Eq. 5-5 with Maximum Test Weight	.485	.94	.485	.94
5. Eq. 5-6 with Curb Weight	.578	1.37	.563	1.29
6. Eq. 5-6 with Inertia Weight	.552	1.23	.58	1.39
7. Eq. 5-6 with Maximum Test Weight	.441	.79	.477	.91
8. Eq. 5-4 with Curb Weight	.602	1.51	.602	1.51
9. Eq. 5-4 with Inertia Weight	.546	1.20	.546	1.20
10. Eq. 5-4 with Maximum Test Weight	.426	0.74	.426	0.74

Source: Reference 24

TABLE 5-18. FUNCTIONAL SUBSYSTEMS FOR DETERMINING WEIGHT COMPOUNDING FACTORS

SUBSYSTEMS THAT ARE AFFECTED BY WEIGHT CHANGE	SUBSYSTEMS THAT ARE NOT AFFECTED BY WEIGHT CHANGE
Body Structure	Electrical System
Frame	Instrument Panel and Controls
Front Suspension	Glass
Rear Suspension	Seats
Brakes	Acoustics and insulation
- Front	Trim
- Rear	Heating and ventilation
- Apply System	Windshield washer and wiper
Powertrain	Doors
- Engine	Deck lid
- Starting System	Hood
- Transmission	
- Drive line	
- Fuel System	
- Exhaust	
- Cooling	
Steering	
Tires	
Wheels	
Bumpers	
- Front	
- Rear	
Front Sheet Metal	

Source: Reference 25

The total effect of the weight change in a vehicle consists of three parts: (R_1), the primary weight change in a subsystem, (R_2), the secondary weight change in the remainder of the vehicle as a direct result of (R_1), and (R_3), the compounded weight change as the result of R_2. If, because of a design change, the weight of subsystem A is changed by an amount R_1, the GVW of the vehicle will also be changed by R_1. The primary change in GVW allows all the remaining vehicle subsystems to be changed by an amount (R_2) depending on their weight influence coefficients. Hence,

$$R_2 = R_1 \; (\text{WICV} - \text{WICA}) \qquad \text{(eq. 5-8)}$$

where WICA is the weight influence coefficient of the subsystem on which the primary weight change is made. The secondary weight change then can be compounded by employing the weight influence coefficient of the total vehicle, i.e.

$$R_3 = R_2 \times \text{WICV} \; . \qquad \text{(eq. 5-9)}$$

The total component compounded weight factor (R_T) for every unit of primary weight change becomes

$$R_T = \frac{R_2 + R_3}{R_1} \qquad \text{(eq. 5-10)}$$

or, after substitutions

$$R_T = (1 + \text{WICV}) \; (\text{WICV} - \text{WICA}) \; . \qquad \text{(eq. 5-11)}$$

It should be noted that the total compounded weight factor depends on the specific subsystem on which the primary weight change is made. Using weight data from 13 1974 GM vehicles (Appendix E), GM derived subsystem weight influence coefficients as shown in Table 5-19.[26] Total compounded weight factors for primary weight changes made in each subsystem are also shown in Table 5-19. Therefore, for every pound of weight change in one of these subsystems, the total vehicle weight changes from a low of 1.58 pounds for the structure subsystem to a high of 2.04 pounds for the rear suspension or steering system.

TABLE 5-19. VEHICLE WEIGHT INFLUENCE COEFFICIENTS

FUNCTIONAL SUBSYSTEM	WEIGHT INFLUENCE COEFFICIENT	TOTAL COMPOUNDED WEIGHT FACTOR
Powertrain	.183	0.76
Structure	.294	0.58
Front Suspension	.021	1.02
Rear Suspension	.013	1.04
Brake System	.038	1.00
Steering System	.011	1.04
Tires	.021	1.02
Wheels	.015	1.03
Bumper System	.048	0.98

5.4.4 Hooven's Methodology

In a vehicle weight study conducted for the Department of Transportation, Hooven and Kennedy[27] grouped the vehicle subsystems into three categories: the product-dependent weight, the weight-dependent weight, and the displacement-dependent weight. Unlike the Ford study,[24] which included all chassis subsystem weights into dependent weight, Hooven divided some of the chassis subsystem weights between two of the three weight groups as shown in Table 5-20.

By defining weight per unit displacement p as

$$p = \frac{W_c + W_x}{D} \qquad \text{(eq. 5-12)}$$

and the weight-dependent factor c as

$$c = \frac{W2}{W1+W3+W4} \qquad \text{(eq. 5-13)}$$

Hooven derived

$$W_c = \frac{(1+c)\ (pW1 + mW_x) + cpW4}{p-m-mc} \qquad \text{(eq. 5-14)}$$

where m is the slope of the line following a least-squares fit of powerplant weight (W_p) correlated with engine displacement (D):

$$W_p = n + mD \quad . \qquad \text{(eq. 5-15)}$$

The influence coefficient relating a change in W_c to a unit change in W1 was found to be:

$$Q_1 = \frac{\partial W_c}{\partial W1} = \frac{p(1+c)}{p-m-mc} \quad . \qquad \text{(eq. 5-16)}$$

Hooven calculated the influence coefficient (Q1) for seventeen vehicles produced for the U.S. market. The results of the calculations are given in Table 5-21. The mean of Q1 is 1.400 with a standard deviation of 0.067. It can be seen from Table 5-21 that

TABLE 5-20. WEIGHT CLASSIFICATION DEFINITIONS BY HOOVEN

1. Independent variables, specified weights

    Product-Dependent Weight, W1

    - Body
    - Frame and Tools
    - Instruments and Electrical
    - 80% of Battery and Alternator
    - 50% of Bumpers
    - 50% of Exhaust System
    - 50% of Steering System
    - 20% of Fuel System
    - Constant, n, of powerplant weight Wp
    - Heating and Ventilating

    Disposable Weight, W4

    - Full load of passengers (@150 lbs/passenger)
    - Luggage (@25 lbs/passenger)
    - All available options
    - Incremental weight of heaviest available body style over that of standard model

    Performance Load, Wx

    - Vehicle load specified for performance evaluation = 300 lbs.

2. Dependent variables, derived weight categories

    Weight-Dependent Weight, W2

    - Suspension
    - Wheels and Tires
    - Brakes
    - 80% of Final Drive
    - 50% of Bumpers
    - 50% of Steering System
    - 50% of Transmission

    Powerplant Weight, Wp

    - Engine
    - 80% of Fuel System
    - 50% of Exhaust System
    - 20% of Final Drive
    - 20% of Battery and Alternator
    - 50% of Transmission

    Displacement-Dependent Weight, W3

    - The portion of the powerplant weight that is dependent on engine power or displacement. W3 = Wp - n

    Curb Weight, Wc

    - The weight of the standard vehicle with liquids but without disposable weight. Wc = W1 + W2 + W3

    Maximum Gross Vehicle Weight, Wg

    - Curb weight plus disposable weight. Wg = W1 + W2 + W3 + W4

Source: Reference 27

TABLE 5-21. DERIVED DATA FOR SEVENTEEN ACTUAL VEHICLES

	VEHICLE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
D (CU. IN.)	302	351	351	170	170	200	318	440	225	225	318	360	140	250	100	68	90
P (LB/CU.IN)	13.5	12.5	13.4	17.4	18.1	16.1	12.8	11.4	15.4	16.5	15.0	12.1	20.7	14.8	26.0	31.2	23.7
WEIGHTS IN POUNDS																	
W1	2386	2513	2668	1726	1774	1833	2235	2818	1974	2029	2748	2444	1722	1973	1570	1319	1253
W2	887	927	1057	614	675	772	892	1139	759	863	1076	1038	616	936	579	413	416
W3	511	653	677	317	327	324	647	752	425	515	655	587	262	491	151	90	161
CURB WEIGHT	3784	4093	4403	2657	2776	2929	3774	4709	3158	3407	4479	4069	2600	3400	2300	1823	1830
INFLUENCE COEFFICIENTS																	
Q1	1.43	1.44	1.45	1.35	1.36	1.41	1.44	1.50	1.39	1.40	1.42	1.50	1.35	1.46	1.33	1.26	1.29
Q4	0.25	0.23	0.25	0.21	0.22	0.25	0.23	0.26	0.22	0.24	0.24	0.27	0.23	0.28	0.23	0.19	0.19
QD	2.21	2.20	2.23	2.18	2.21	2.25	2.21	2.24	2.20	2.24	2.23	2.26	2.23	2.29	2.24	2.17	2.18

VEHICLES STUDIED

1. 1970 FORD CUSTOM 500
2. 1972 FORD CUSTOM 500
3. 1974 FORD GALAXIE 500
4. 1970 MAVERICK
5. 1972 MAVERICK
6. 1974 MAVERICK
7. 1974 PLYMOUTH SATELLITE
8. 1974 CHRYSLER NEW YORKER
9. 1976 VALIANT
10. 1976 PLYMOUTH VOLARE
11. 1976 PLYMOUTH GRAN FURY
12. 1976 CHARGER SE
13. 1975 VEGA
14. 1975 NOVA
15. C6
16. 1972 FIAT 128
17. 1975 VW RABBIT

Source: Reference 27

the values of Q1 are nearly the same for all vehicles. Therefore, the influence coefficient (Q1) is constant and does not depend on the vehicle being studied. Thus, Hooven concluded that every decrease of one pound in the weight of a body component could lead to a total vehicle weight reduction of 1.4 pounds, assuming that the weight-dependent components are redesigned appropriately for the smaller load they must support.

5.4.5 TSC Methodology

The methodologies for deriving weight propagation factors which have been discussed have two major drawbacks. First, these methodologies are essentially statistical analyses. They rely on weight data of vehicles which, in most cases, are pre-1975 models. Therefore, the results derived represent only past or present technology; hence, they cannot be used to project weight of future vehicles when more and larger quantities of lightweight materials are expected to be used. Secondly, the results derived are affected greatly by how and what subsystems are grouped into different weight categories. The procedure of dividing and grouping component weights into subsystems sometimes involves more subjective judgment than objective consideration based on engineering design.

In order to overcome these shortcomings, a methodology which will take into consideration the changes in applied load, the structural characteristics, and the material properties of each component is being developed. It is expected that the new methodology will allow a weight propagation factor to be derived for each component or for each group of components independent of vehicle type and model year. This methodology will be described in the forth coming 1980 Summary Source Document.

6. EFFECTS OF WEIGHT REDUCTION

6.1 VEHICLE PERFORMANCE

There are currently two performance parameters in use that provide a measure of the acceleration capability of a motor vehicle. These are:

a) the time period required to attain the speed of 60 mph (88 ft/sec) from the position of rest;

b) the time required to increase the speed from 40 mph (58.67 ft/sec) to 60 mph (88 ft/sec).

The parameter under b) is characteristic for the vehicle's potential of passing another vehicle.

Both parameters a) and b) depend on the available engine thrust at the wheels to accelerate the vehicle and to overcome the rolling resistance of tires and the aerodynamic drag. Consideration of all factors including the constraint imposed by possible tire slip, i.e. the tire thrust force exceeds the maximal ground resistance, leads to a first order nonlinear differential equation of the Ricatti type.[28] The solution of the equation indicates a nearly linear relationship between speed and time. Assuming equal thrust available to both vehicles at curb weight, the reduced weight vehicle requires a fraction of a second more time to reach 60 mph than the original weight vehicle when starting from the position of rest because the weight reduction diminishes the useful thrust force exerted at the wheels due to tire slip. However, once the vehicle reaches 15 to 20 mph, the reduced rolling resistance allows greater acceleration even though that advantage is negligible in comparison to aerodynamic drag which is identical for both vehicles for assumed identical body styles.

6.2 VEHICLE HANDLING

Aside from the critical cornering characteristics of pneumatic tires, vehicle handling is affected by axle load distribution or location of vehicle sprung mass center of gravity, and the length of the radius of gyration. The latter depends on mass distribution of the sprung masses and their density. Unsprung masses (axles, wheels and linkages) are primary targets for weight reduction and vehicle ride quality is favorably affected.

In the following, some aspects of vehicle handling in relation to weight reduction are discussed. The data are extracted from Reference 28 and are based on the assumptions which are summarized in Table 6-1 below.

TABLE 6.1. INFLUENCE OF WEIGHT REDUCTION ON VEHICLE HANDLING

Original vehicle curb weight:		5572 lb
weight reduction		2229 lb
weight ratio	ε =	$\frac{5572-2229}{5572} = .6$
Original weight vehicle radius of gyration	ρ =	5.3 ft (horizontal plane)
Reduced weight vehicle radius of gyration	ρ_1 =	4.7 ft (horizontal plane)
Ratio of squares of radius of gyration	ν^2 =	$\frac{4.7^2}{5.3^2} = .8$

Vehicle handling characteristics are based on 60 mph forward speed for a vehicle with understeer.

If r (mr sec^{-1}) denotes the yaw rate of a vehicle negotiating a curve, u is the forward speed (ft/sec), δ is the steer angle (mr), ω is the wheel base (ft); it can be shown that the inequality or equality $\frac{r\omega}{u} \gtreqless \delta$ represents over steer, neutral steer, or understeer.

This formula, if expressed in words, states: A vehicle has oversteer when its normalized yaw rate $r/(u/\omega)$ exceeds the steer angle of wheels, neutral steer when it is equal to the steer angle, and understeer when it is less than the steer angle. This definition holds also when the steer angle of wheels is zero and initially the only lateral force is a wind gust force.[29] In Reference 28, the vehicle responses for a 1° (17.45 mr) change of wheel steering angle were simulated and yielded the following results:

Original weight vehicle (o.w.v.)

$$\frac{r\,\omega}{u} = 11 \text{ mr} < \delta = 17.45 \text{ mr}$$

hence, according to the definition above, the vehicle has understeer. The reduced weight vehicle (r.w.v.) (ε = .6, v^2 = .8) yielded the same degree of understeer,

$$\frac{r\,\omega}{u} = 11 \text{ mr} < \delta = 17.45 \text{ mr}$$

and therefore no change of the steering qualities or stability behavior was observed during the simulation. However, there was a substantial difference between relative front and rear tire slip angles defined as:

$$\alpha_f = (v+ar)/u \text{ and}$$

$$\alpha_r = (v-br)/u$$

where,

v denotes side slip velocity,

a is the distance between the mass center and front wheel axis

b is the distance between the mass center and rear wheel axis.

Front wheel slip angles are 19 mr (o.w.v); 13 mr (r.w.v.) and rear wheel slip angles are 8 mr (o.w.v.); 2 mr (r.w.v.).

Another convenient parameter that may be obtained from vehicle drive simulations is the lateral acceleration during steady-state curvilinear motion or peak lateral acceleration if a steer angle pulse is introduced. Lateral acceleration

$$a_y = \frac{u^2}{\rho_c}$$

where ρ_c is the radius of curvature of the vehicle trajectory. This acceleration can be expressed in multiples of the gravitational constant g such that,

$$a_y = ((u^2/\rho_c)/g) \cdot g$$

where $(u^2/\rho_c)/g$ is a proportionality factor. The result of the simulation yielded

$$a_y = .231 \text{ g (o.w.v.)}$$

$$a_y = .231 \text{ g (r.w.v.)}$$

Comment: no change.

While lateral acceleration and amount of understeer are virtually unchanged, the yaw rate, r, and side slip velocity, v, show the effects of weight reduction. The yaw rate of the original weight vehicle amounted to 75 mr/sec while that of the reduced weight vehicle amounted to 100 mr/sec. This is an increase of 33 percent over the yaw rate of the original weight vehicle. The side slip velocity of the original weight vehicle gave 1.25 ft/sec and that of the reduced weight vehicle 0.625 ft/sec, that is a significant reduction (approximately 50 percent). Recent research in the field of human factors seems to indicate a higher sensitivity of vehicle occupants relative to yaw than to side slip and therefore the 33 percent increase in yaw rate for the reduced weight vehicle may require some changes in the assumed tire characteristics and the location of the vehicle's center of gravity.

Similarly, the roll deflection of the original weight vehicle amounted to 37.5 mr, whereas that of the reduced weight vehicle amounted to 45 mr, a 20 percent increase. Again, this increase may be sensed by the vehicle occupants and could be prevented by lowering the center of gravity.

The drive simulations indicated that the response time to changes in the steer angle is 20 percent lower in the reduced weight vehicle when compared with the original weight vehicle, indicating a greater sensitivity. This result is expected since the inertial properties of the system had been reduced. The steer angle input function was chosen in the form of a square wave, trapezoidal wave and sinusoidal wave pulse of 1 sec duration. In all three cases, the maximal deflection amplitude was set at 1° or 17.45 mr. Except for transient effects, the output of the system indicated the linear dependence between system variables in correspondence with the selected linear model representation.

6.3 RIDE QUALITY

The road profile was assumed to be composed of sine waves of 1 in amplitude and different wave lengths. If the vehicle speed is is u (ft/sec), ℓ' is the wave length and ℓ is the wheel base, then

$$y = (1)\ \text{Sin}\ 2\pi x/\ell' = 1\ \text{Sin}\ wt \qquad \text{(eq. 6-1)}$$

where

$$wt = 2\pi x/\ell' = 2\pi ut/\ell' \qquad \text{(eq. 6-2)}$$

and x = ut, w is circular frequency, t is time, x is forward displacement.

So, $$w = 2\pi u/\ell' \qquad \text{(eq. 6-3)}$$

Let $$w\tau = 2\pi = 2\pi u\tau/\ell' \qquad \text{(eq. 6-3a)}$$

It follows $$\tau = 2\pi/w \qquad \text{(eq. 6-3b)}$$

and $$\ell' = 2\pi u/w\ . \qquad \text{(eq. 6-3c)}$$

Equations (6-1) to (6-3) relate the spatial variable x, y to the variable t. Obviously front and rear wheel lift do not necessarily occur simultaneously and the vehicle, assumed to have two degrees of freedom (bounce and pitch), must respond to both inputs, namely at the front and at the rear wheels. Hence the relationship between wavelength ℓ' and wheel base ℓ must be introduced into (6-1).

Let

$$2\pi\ell/\ell' = \alpha \qquad \text{(eq. 6-4)}$$

be the phase angle by which the front wheel input leads the rear wheel input. Then

$$y_{front} = 1\ \text{Sin}\ (2\pi(ut/\ell')+\alpha) \qquad \text{(eq. 6-5)}$$

$$y_{rear} = 1\ \text{Sin}\ (2\pi ut/\ell') \qquad \text{(eq. 6-1a)}$$

and (6-5) can be written as

$$y_{front} = 1\ \text{Sin}\ 2\pi\left(\frac{ut}{\ell'} + \frac{\ell}{\ell'}\right) \qquad \text{(eq. 6-5a)}$$

where in (6-5a)

$$o < \ell/\ell' < \infty$$

two extreme values of the phase angle α are:

$$\alpha = \frac{2n+1}{2}\pi \qquad (n = 0, 1, 2, 3, \ldots) \qquad \text{(eq. 6-6)}$$

and

$$\alpha = (n+1)\pi \quad .$$

Then

$$\ell/\ell' = \frac{2n+1}{4} \qquad \text{(eq. 6-7)}$$

and

$$\ell/\ell' = \frac{n+1}{2}$$

respectively.

With the first of relations (6-6), (6-7) one associates out-of-phase motion input, and with the second set in-phase motion input. During out-of-phase motion the unsprung masses move in opposed directions whereas during the in-phase motion they move in the same directions, but not necessarily synchronously, because of parameter variations between front and rear suspension and masses. The ride quality program was exercised employing a four degree of freedom model, namely sprung mass pitch and bounce motion and one degree of freedom each for front and rear unsprung masses.[28] Only pitch and bounce motion modes for in-phase and out-of-phase motion were recorded at different forward speeds.

The results indicated that the response was most severe in the speed range of 7-1/2 mph to 15 mph at the first resonant speed. Weight reduction was shown to have insignificant effects on the response amplitudes. However, the forward speeds at which the original weight vehicle and the reduced weight vehicle have equal pitch or equal bounce amplitudes are significantly different. In other words, the amplitude versus frequency diagrams (reasonance curves) are shifted towards the higher frequency values for the reduced weight vehicle as shown in the following example. Given an amplitude of .01 inch in the bounce mode (out-of-phase input) the speed of the original weight vehicle was 13.5 mph, and that of the reduced weight vehicle was 16.5 mph, that is 22 percent higher. A similar result was obtained for the pitch motion mode.

Over a wide speed range, weight reduction of sprung and unsprung masses favors ride quality, if the suspensions are tailored to the vehicle design. This will require lower rate springs, increased axle clearance and slightly increased schock absorber resistance. In general, the greater the payload, the softer the ride for both vehicle types considered herein, but the percentage of improvement is greater for the reduced weight vehicle. On the other hand, the risk of bottoming of springs and thereby transmitting jolts to the vehicle occupants and cargo is also increased. In order to prevent frequently exhausting the available axle clearance under limit load conditions, the use of so-called "load levellers" (hydraulic or mechanical) may be well advised.

6.4 NOISE SUPPRESSION

Interior automotive noise is produced by the powertrain, aerodynamic turbulence, tire-road contact, suspension vibration, etc. In general, passenger compartment noise is inversely proportional to vehicle size and mass. The relationship exists for several reasons:

1. Replacing smooth running, low RPM eight and six cylinder engines with vibration prone, higher RPM four cylinder engines increases under-hood noise.

2. Replacing conventional steel with high strength steel with commensurate structural properties, but thinner gauge, allows more noise to be transmitted through the body.

3. To save weight, there is an increasing tendency to employ unit body construction and eliminate the frame. This practice exacerbates the problem of isolating the passenger compartment from road noise and suspension vibration.

4. Small diameter, low-volume tires tend to produce a rougher ride than larger, high-volume tires. Also, increasing tire pressure, which reduces rolling resistance and improves fuel economy, reduces tire shock absorption characteristics. These factors translate into increased suspension vibration.

5. In an effort to save weight, manufacturers are generally using thinner carpets, which have reduced noise absorption capacity. This allows increased levels of road noise to be transmitted into the passenger compartment.

6. For weight reduction, windshield glass often is reduced in thickness by approximately 20 percent; other automotive glass is usually reduced by approximately 33 percent. These decreases permit more aerodynamic noise to enter the interior sections.

Therefore, unless substantial effort is put into noise suppression, interior noise levels will increase with the implementation of weight reduction programs.

The human ear can perceive frequencies ranging from 25 to 16,000 hertz, but is most sensitive to those between 500 and 6,000 hertz.[30] As Figure 6.1 shows, significant interior compartment noise is within the occupant's most sensitive hearing range.

Sound reflection and absorption are the primary methods of reducing vehicular interior sound levels. The sound absorption performance of a material is expressed as:

$$A = 10 \log_{10} \frac{\alpha_i}{\alpha_o} , \quad o < \alpha \leq 1$$

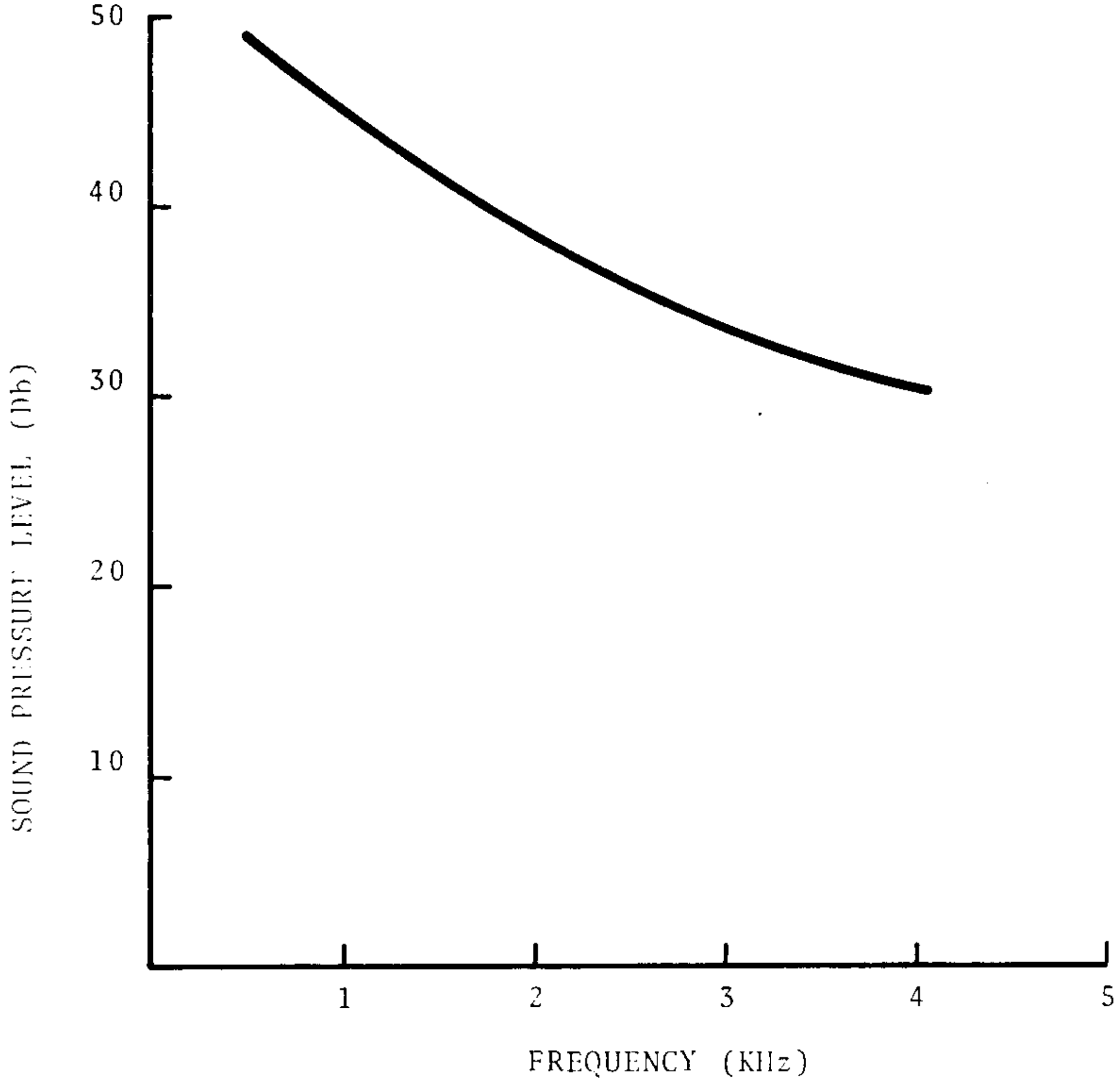
where A = Decibels absorbed by sound insulation

α_o = Original absorption coefficient

α_i = Insulation absorption coefficient.

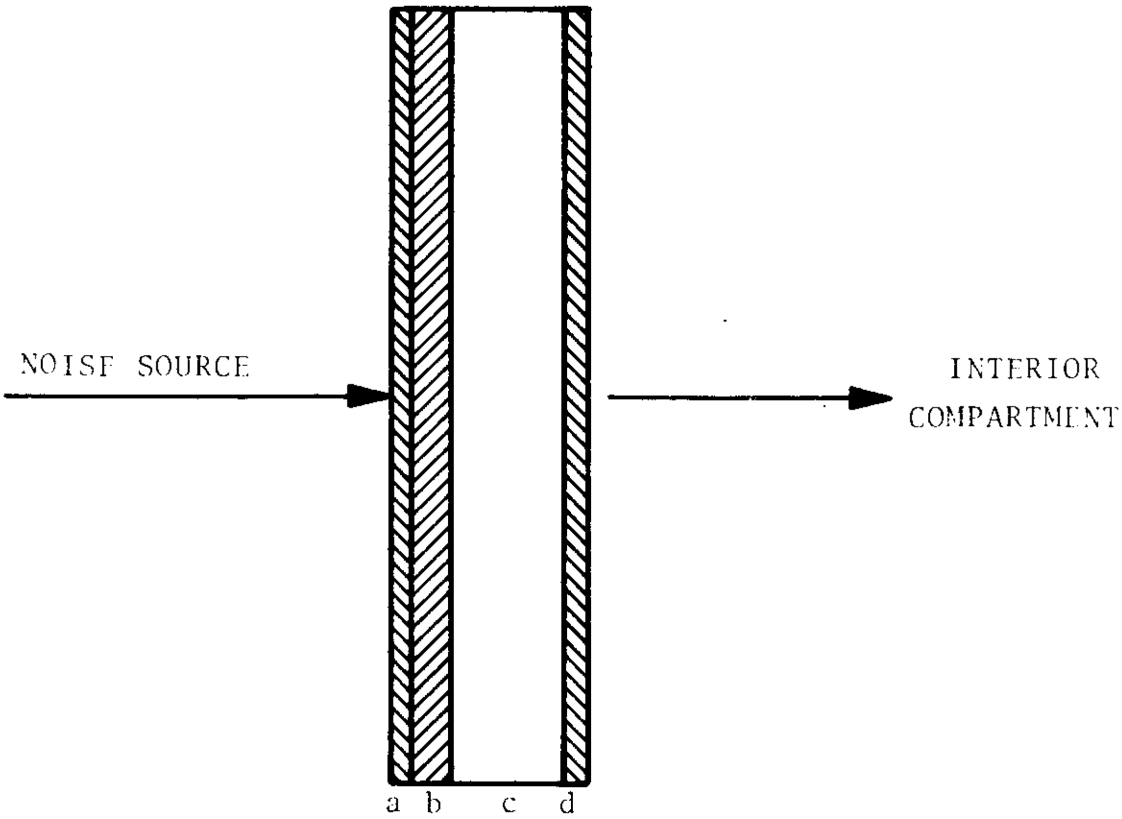
The sound absorption coefficient usually increases with noise frequency. This increase in absorption efficiency with frequency contributes to the trend shown in Figure 6-1 of the interior sound level decreasing with frequency.

The required sound insulation must be light weight to avoid negating the effect of overall vehicular weight reduction. Uchiyamada and Kunieda found empirically that the laminated structure shown in Figure 6-2 functions most effectively for passenger compartment noise suppression.[31] These laminated materials



SOURCE: Reference 31

FIGURE 6-1. NOISE VS. FREQUENCY FOR FRONT SEAT OF SUBCOMPACT AUTOMOBILE WITH ENGINE OPERATING AT 3,000 RPM



a = Steel sheet

b = Damping sheet

c = Porous material

d = Vinyl choloride sheet

FIGURE 6-2. STRUCTURE OF NOISE SUPPRESSION MATERIAL produce a decrease of three to four decibels from the original interior noise level.

To ensure safety and maketability as vehicles are made progressively smaller and lighter, continued attention must be given to maintaining passenger compartment noise at an acceptable level.

APPENDIX A
AUTOMOBILE MATERIAL SUBSTITUTION

This appendix summarizes original material and weight of selected vehicular components and the weight of replacement components for the three baseline passenger vehicles. For each baseline vehicle, four alternative material dominant cases are presented. Table A1 through A4, A5 through A8, and A9 through A12 tabulate component data for the 1978 Omni, 1978 Fairmont, and 1977 Impala, respectively.

TABLE A-1 1978 CHRYSLER OMNI 4-DOOR HATCHBACK EQUIPPED WITH 105 CID ENGINE, HSS DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
FRONT FENDER PANEL	STEEL	27.6	HSS	22.9
FENDER EXTENSION & MOUNTING	STEEL	2.4	HSS	1.9
HOOD OUTER PANEL	HSS	17.8	HSS	17.8
HOOD INNER PANEL	STEEL	11.0	HSS	9.1
HOOD HINGE	HSS	2.3	HSS	2.3
RADIATOR CROSSMEMBER	STEEL	2.5	HSS	2.0
HOOD LAMP PANEL	STEEL	10.4	HSS	8.6
FRONT DOOR OUTER PANEL	STEEL	18.4	HSS	15.3
FRONT DOOR INNER PANEL	STEEL	16.4	HSS	13.6
FRONT DOOR HINGE & BRACKET	STEEL	9.2	HSS	7.4
FRONT DOOR GUARD BEAM	HSS	11.3	HSS	11.3
FRONT DOOR WINDOW FRAME	STEEL	7.5	HSS	6.0
REAR DOOR OUTER PANEL	STEEL	13.6	HSS	11.3
REAR DOOR INNER PANEL	STEEL	12.5	HSS	10.4
REAR DOOR PILLAR	HSS	5.9	HSS	5.9
REAR DOOR GUARD BEAM	HSS	7.0	HSS	7.0
REAR DOOR WINDOW FRAME	STEEL	7.8	HSS	6.2
REAR DOOR HINGE & BRACKET	STEEL	3.6	HSS	2.9
SIDE SILL PANEL	STEEL	40.1	HSS	33.3
BODY PILLAR	HSS	12.5	HSS	12.5
QUARTER PANEL & WHEEL WELL	STEEL	29.6	HSS	24.6
LIFT GATE TROUGH & SUPPORT	STEEL	9.2	HSS	7.4
SHOCK ABSORBER REINFORCEMENT	HSS	4.5	HSS	4.5
LIFT GATE OUTER PANEL	STEEL	10.1	HSS	8.4
LIFT GATE INNER PANEL	STEEL	8.4	HSS	7.0
LIFT GATE HINGE & SUPPORT	STEEL	3.9	HSS	3.1
DECK OPENING PANEL	STEEL	9.6	HSS	8.0
DECK OPENING SUPPORT	STEEL	2.9	HSS	2.3

TABLE A-1 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
ROOF OUTER PANEL	STEEL	24.2	HSS	20.1
ROOF RAIL, BOW, & SUPPORT	STEEL	10.8	HSS	8.6
DASH PANEL	STEEL	12.4	HSS	10.3
DASH PANEL FRAME	STEEL	7.9	HSS	6.3
COWL TOP & SIDE PANEL	STEEL	19.7	HSS	16.4
COWL SUPPORT & FRAME	STEEL	14.9	HSS	11.9
BODY FRONT PILLAR & SUPPORT	HSS	10.7	HSS	10.7
FLOOR PAN	STEEL	59.7	HSS	49.6
SPARE TIRE WELL	STEEL	10.1	HSS	8.4
FLOOR PAN CROSSMEMBER	STEEL	10.4	HSS	8.3
SIDE RAIL & SILL	STEEL	27.3	HSS	21.8
UNDER BODY BRACKET & BRACE	STEEL	19.2	HSS	15.4
INSTRUMENT PANEL COVER	STEEL	2.9	HSS	2.4
FRONT FRAME	HSS	53.9	HSS	53.9
CROSSMEMBER & STRUT	STEEL	21.2	HSS	17.0
FRONT TOWER	STEEL	5.1	HSS	4.1
TOWER REINFORCEMENT	HSS	4.1	HSS	4.1
BATTERY TRAY	STEEL	3.0	HSS	2.5
FRONT SEAT TRACK	STEEL	9.9	HSS	7.9
FRONT SEAT FRAME	STEEL	29.4	HSS	23.5
REAR SEAT FRAME	STEEL	14.1	HSS	11.3
REAR SEAT PIN & BRACKET	STEEL	1.2	HSS	1.0
FRONT BUMPER	ALUM	8.6	ALUM	8.6
REAR BUMPER	ALUM	8.3	ALUM	8.3
FRONT COIL SPRING	STEEL	16.9	HRP	6.8
FRONT CONTROL ARM	STEEL	8.2	HSS	6.6
SWAYBAR	STEEL	10.1	HSS	8.1
REAR COIL SPRING	STEEL	8.7	HSS	3.5

TABLE A-1 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
REAR CONTROL ARM	STEEL	16.9*	HSS	13.5
REAR SUSPENSION "X" MEMBER	HSS	20.0*	HSS	20.0
ENGINE BLOCK	IRON	71.9	IRON	71.9
CYLINDER HEAD	ALUM	17.7	ALUM	17.7
CONNECTING ROD	STEEL	5.0	STEEL	5.0
VALVE COVER	STEEL	1.9	HSS	1.6
OIL PAN	STEEL	5.9	HSS	4.9
AIR CLEANER	STEEL	3.5*	HSS	2.9
INTAKE MANIFOLD	ALUM	3.2	ALUM	3.2
EXHAUST MANIFOLD	IRON	8.2	STAINLESS STEEL	3.1
ENGINE MOUNT	STEEL	6.6*	HSS	5.3
CLUTCH DUST COVER	STEEL	1.0	HSS	0.8
FUEL TANK	TERNE	14.0	HDPE	9.1
FRONT BRAKE DISC	IRON	14.2	ALUM	7.1
FRONT BRAKE SPLASH SHIELD	STEEL	0.8	HSS	0.7
REAR BRAKE DRUM	IRON	21.4	ALUM	10.7
BRAKE PEDAL	HSS	2.9	HSS	2.9
PARKING BRAKE LEVEL	STEEL	2.8	HSS	2.2
GEAR SHIFT BRACKET	HSS	2.1	HSS	2.1
WHEEL	STEEL	81.3	ALUM	40.7
MISC. BRACKET & SUPPORT	STEEL	14.3	HSS	11.4

*ESTIMATED.

TABLE A-2 1978 CHRYSLER ONMI 4-DOOR HATCHBACK
EQUIPPED WITH 105 CID ENGINE,
FRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
FRONT FENDER PANEL	STEEL	27.6	FRP	21.5
FENDER EXTENSION & MOUNTING	STEEL	2.4	HSS	1.9
HOOD OUTER PANEL	HSS	17.8	FRP	16.7
HOOD INNER PANEL	STEEL	11.0	FRP	8.6
HOOD HINGE	HSS	2.3	HSS	2.3
RADIATOR CROSSMEMBER	STEEL	2.5	HSS	2.0
HOOD LAMP PANEL	STEEL	10.4	FRP	8.1
FRONT DOOR OUTER PANEL	STEEL	18.4	FRP	14.4
FRONT DOOR INNER PANEL	STEEL	16.4	FRP	12.8
FRONT DOOR HINGE & BRACKET	STEEL	9.2	HSS	7.4
FRONT DOOR GUARD BEAM	HSS	11.3	HSS	11.3
FRONT DOOR WINDOW FRAME	STEEL	7.5	HSS	6.0
REAR DOOR OUTER PANEL	STEEL	13.6	FRP	10.6
REAR DOOR INNER PANEL	STEEL	12.5	FRP	9.8
REAR DOOR PILLAR	HSS	5.9	HSS	5.9
REAR DOOR GUARD BEAM	HSS	7.0	HSS	7.0
REAR DOOR WINDOW FRAME	STEEL	7.8	HSS	6.2
REAR DOOR HINGE & BRACKET	STEEL	3.6	HSS	2.9
SIDE SILL PANEL	STEEL	40.1	FRP	31.3
BODY PILLAR	HSS	12.5	HSS	12.5
QUARTER PANEL & WHEEL WELL	STEEL	29.6	FRP	23.1
LIFT GATE TROUGH & SUPPORT	STEEL	9.2	HSS	7.4
SHOCK ABSORBER REINFORCEMENT	HSS	4.5	HSS	4.5
LIFT GATE OUTER PANEL	STEEL	10.1	FRP	7.9
LIFT GATE INNER PANEL	STEEL	8.4	FRP	6.6
LIFT GATE HINGE & SUPPORT	STEEL	3.9	HSS	3.1
DECK OPENING PANEL	STEEL	9.6	FRP	7.5
DECK OPENING SUPPORT	STEEL	2.9	HSS	2.3

TABLE A-2 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
ROOF OUTER PANEL	STEEL	24.2	FRP	18.9
ROOF RAIL, BOW, & SUPPORT	STEEL	10.8	HSS	8.6
DASH PANEL	STEEL	12.4	FRP	9.7
DASH PANEL FRAME	STEEL	7.9	HSS	6.3
COWL TOP & SIDE PANEL	STEEL	19.7	FRP	15.4
COWL SUPPORT & FRAME	STEEL	14.9	HSS	11.9
BODY FRONT PILLAR & SUPPORT	HSS	10.7	HSS	10.7
FLOOR PAN	STEEL	59.7	FRP	46.6
SPARE TIRE WELL	STEEL	10.1	FRP	7.9
FLOOR PAN CROSSMEMBER	STEEL	10.4	HSS	8.3
SIDE RAIL & SILL	STEEL	27.3	HSS	21.8
UNDER BODY BRACKET & BRACE	STEEL	19.2	HSS	15.4
INSTRUMENT PANEL COVER	STEEL	2.9	FRP	2.3
FRONT FRAME	HSS	53.9	HSS	53.9
CROSSMEMBER & STRUT	STEEL	21.2	HSS	17.0
FRONT TOWER	STEEL	5.1	HSS	4.1
TOWER REINFORCEMENT	HSS	4.1	HSS	4.1
BATTERY TRAY	STEEL	3.0	FRP	2.3
FRONT SEAT TRACK	STEEL	9.9	HSS	7.9
FRONT SEAT FRAME	STEEL	29.4	HSS	23.5
REAR SEAT FRAME	STEEL	14.1	HSS	11.3
REAR SEAT PIN & BRACKET	STEEL	1.2	HSS	1.0
FRONT BUMPER	ALUM	8.6	ALUM	8.6
REAR BUMPER	ALUM	8.3	ALUM	8.3
FRONT COIL SPRING	STEEL	16.9	HRP	6.8
FRONT CONTROL ARM	STEEL	8.2	HSS	6.6
SWAYBAR	STEEL	10.1	HSS	8.1
REAR COIL SPRING	STEEL	8.7	HRP	3.5

TABLE A-2 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
REAR CONTROL ARM	STEEL	16.9*	HSS	13.5
REAR SUSPENSION "X" MEMBER	HSS	20.0*	HSS	20.0
ENGINE BLOCK	IRON	71.9	IRON	71.9
CYLINDER HEAD	ALUM	17.7	ALUM	17.7
CONNECTING ROD	STEEL	5.0	STEEL	5.0
VALVE COVER	STEEL	1.9	FRP	1.5
OIL PAN	STEEL	5.9	FRP	4.6
AIR CLEANER	STEEL	3.5*	FRP	2.7
INTAKE MANIFOLD	ALUM	3.2	ALUM	3.2
EXHAUST MANIFOLD	IRON	8.2	STAINLESS STEEL	3.1
ENGINE MOUNT	STEEL	6.6*	HSS	5.3
CLUTCH DUST COVER	STEEL	1.0	FRP	0.8
FUEL TANK	TERNE	14.0	HDPE	9.1
FRONT BRAKE DISC	IRON	14.2	ALUM	7.1
FRONT BRAKE SPLASH SHIELD	STEEL	0.8	FRP	0.6
REAR BRAKE DRUM	IRON	21.4	ALUM	10.7
BRAKE PEDAL	HSS	2.9	HSS	2.9
PARKING BRAKE LEVEL	STEEL	2.8	HSS	2.2
GEAR SHIFT BRACKET	HSS	2.1	HSS	2.1
WHEEL	STEEL	81.3	HRP	32.5
MISC. BRACKET & SUPPORT	STEEL	14.3	HSS	11.4

*ESTIMATED.

TABLE A-3 1978 CHRYSLER OMNI 4-DOOR HATCHBACK
EQUIPPED WITH 105 CID ENGINE,
ALUMINUM DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
FRONT FENDER PANEL	STEEL	27.6	ALUM	16.0
FENDER EXTENSION & MOUNTING	STEEL	2.4	HSS	1.9
HOOD OUTER PANEL	HSS	17.8	ALUM	12.4
HOOD INNER PANEL	STEEL	11.0	ALUM	6.4
HOOD HINGE	HSS	2.3	HSS	2.3
RADIATOR CROSSMEMBER	STEEL	2.5	HSS	2.0
HOOD LAMP PANEL	STEEL	10.4	ALUM	6.0
FRONT DOOR OUTER PANEL	STEEL	18.4	ALUM	10.7
FRONT DOOR INNER PANEL	STEEL	16.4	ALUM	9.5
FRONT DOOR HINGE & BRACKET	STEEL	9.2	HSS	7.4
FRONT DOOR GUARD BEAM	HSS	11.3	HSS	11.3
FRONT DOOR WINDOW FRAME	STEEL	7.5	HSS	6.0
REAR DOOR OUTER PANEL	STEEL	13.6	ALUM	7.9
REAR DOOR INNER PANEL	STEEL	12.5	ALUM	7.3
REAR DOOR PILLAR	HSS	5.9	HSS	5.9
REAR DOOR GUARD BEAM	HSS	7.0	HSS	7.0
REAR DOOR WINDOW FRAME	STEEL	7.8	HSS	6.2
REAR DOOR HINGE & BRACKET	STEEL	3.6	HSS	2.9
SIDE SILL PANEL	STEEL	40.1	ALUM	23.3
BODY PILLAR	HSS	12.5	HSS	12.5
QUARTER PANEL & WHEEL WELL	STEEL	29.6	ALUM	17.2
LIFT GATE TROUGH & SUPPORT	STEEL	9.2	HSS	7.4
SHOCK ABSORBER REINFORCEMENT	HSS	4.5	HSS	4.5
LIFT GATE OUTER PANEL	STEEL	10.1	ALUM	5.9
LIFT GATE INNER PANEL	STEEL	8.4	ALUM	4.9
LIFT GATE HINGE & SUPPORT	STEEL	3.9	HSS	3.1
DECK OPENING PANEL	STEEL	9.6	ALUM	5.6
DECK OPENING SUPPORT	STEEL	2.9	HSS	2.3

TABLE A-3 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
ROOF OUTER PANEL	STEEL	24.2	ALUM	14.0
ROOF RAIL, BOW, & SUPPORT	STEEL	10.8	HSS	8.6
DASH PANEL	STEEL	12.4	ALUM	7.2
DASH PANEL FRAME	STEEL	7.9	HSS	6.3
COWL TOP & SIDE PANEL	STEEL	19.7	ALUM	11.4
COWL SUPPORT & FRAME	STEEL	14.9	HSS	11.9
BODY FRONT PILLAR & SUPPORT	HSS	10.7	HSS	10.7
FLOOR PAN	STEEL	59.7	ALUM	34.6
SPARE TIRE WELL	STEEL	10.1	ALUM	5.9
FLOOR PAN CROSSMEMBER	STEEL	10.4	HSS	8.3
SIDE RAIL & SILL	STEEL	27.3	HSS	21.8
UNDER BODY BRACKET & BRACE	STEEL	19.2	HSS	15.4
INSTRUMENT PANEL COVER	STEEL	2.9	ALUM	1.7
FRONT FRAME	HSS	53.9	HSS	53.9
CROSSMEMBER & STRUT	STEEL	21.2	HSS	17.0
FRONT TOWER	STEEL	5.1	HSS	4.1
TOWER REINFORCEMENT	HSS	4.1	HSS	4.1
BATTERY TRAY	STEEL	3.0	ALUM	1.7
FRONT SEAT TRACK	STEEL	9.9	HSS	7.9
FRONT SEAT FRAME	STEEL	29.4	HSS	23.5
REAR SEAT FRAME	STEEL	14.1	HSS	11.3
REAR SEAT PIN & BRACKET	STEEL	1.2	HSS	1.0
FRONT BUMPER	ALUM	8.6	ALUM	8.6
REAR BUMPER	ALUM	8.3	ALUM	8.3
FRONT COIL SPRING	STEEL	16.9	HRP	6.8
FRONT CONTROL ARM	STEEL	8.2	HSS	6.6
SWAYBAR	STEEL	10.1	HSS	8.1
REAR COIL SPRING	STEEL	8.7	HRP	3.5

TABLE A-3 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
REAR CONTROL ARM	STEEL	16.9*	HSS	13.5
REAR SUSPENSION "X" MEMBER	HSS	20.0*	HSS	20.0
ENGINE BLOCK	IRON	71.9	ALUM	36.0
CYLINDER HEAD	ALUM	17.7	ALUM	17.7
CONNECTING ROD	STEEL	5.0	STEEL	5.0
VALVE COVER	STEEL	1.9	ALUM	1.1
OIL PAN	STEEL	5.9	ALUM	3.4
AIR CLEANER	STEEL	3.5*	ALUM	2.0
INTAKE MANIFOLD	ALUM	3.2	ALUM	3.2
EXHAUST MANIFOLD	IRON	8.2	STAINLESS STEEL	3.1
ENGINE MOUNT	STEEL	6.6*	HSS	5.3
CLUTCH DUST COVER	STEEL	1.0	ALUM	0.6
FUEL TANK	TERNE	14.0	HDPE	9.1
FRONT BRAKE DISC	IRON	14.2	ALUM	7.1
FRONT BRAKE SPLASH SHIELD	STEEL	0.8	ALUM	0.5
REAR BRAKE DRUM	IRON	21.4	ALUM	10.7
BRAKE PEDAL	HSS	2.9	HSS	2.9
PARKING BRAKE LEVEL	STEEL	2.8	HSS	2.2
GEAR SHIFT BRACKET	HSS	2.1	HSS	2.1
WHEEL	STEEL	81.3	ALUM	40.7
MISC. BRACKET & SUPPORT	STEEL	14.3	HSS	11.4

*ESTIMATED.

TABLE A-4 1978 CHRYSLER OMNI 4-DOOR HATCHBACK
EQUIPPED WITH 105 CID ENGINE,
HRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
FRONT FENDER PANEL	STEEL	27.6	HRP	13.8
FENDER EXTENSION & MOUNTING	STEEL	2.4	HRP	1.0
HOOD OUTER PANEL	HSS	17.8	HRP	10.7
HOOD INNER PANEL	STEEL	11.0	HRP	5.5
HOOD HINGE	HSS	2.3	HRP	1.2
RADIATOR CROSSMEMBER	STEEL	2.5	HRP	1.0
HOOD LAMP PANEL	STEEL	10.4	HRP	5.2
FRONT DOOR OUTER PANEL	STEEL	18.4	HRP	9.2
FRONT DOOR INNER PANEL	STEEL	16.4	HRP	8.2
FRONT DOOR HINGE & BRACKET	STEEL	9.2	HRP	3.7
FRONT DOOR GUARD BEAM	HSS	11.3	HRP	5.7
FRONT DOOR WINDOW FRAME	STEEL	7.5	HRP	3.0
REAR DOOR OUTER PANEL	STEEL	13.6	HRP	6.8
REAR DOOR INNER PANEL	STEEL	12.5	HRP	6.3
REAR DOOR PILLAR	HSS	5.9	HRP	3.0
REAR DOOR GUARD BEAM	HSS	7.0	HRP	3.5
REAR DOOR WINDOW FRAME	STEEL	7.8	HRP	3.1
REAR DOOR HINGE & BRACKET	STEEL	3.6	HRP	1.4
SIDE SILL PANEL	STEEL	40.1	HRP	20.1
BODY PILLAR	HSS	12.5	HRP	6.3
QUARTER PANEL & WHEEL WELL	STEEL	29.6	HRP	14.8
LIFT GATE TROUGH & SUPPORT	STEEL	9.2	HRP	3.7
SHOCK ABSORBER REINFORCEMENT	HSS	4.5	HRP	2.3
LIFT GATE OUTER PANEL	STEEL	10.1	HRP	5.1
LIFT GATE INNER PANEL	STEEL	8.4	HRP	4.2
LIFT GATE HINGE & SUPPORT	STEEL	3.9	HRP	1.6
DECK OPENING PANEL	STEEL	9.6	HRP	4.8
DECK OPENING SUPPORT	STEEL	2.9	HRP	1.2

TABLE A-4 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
ROOF OUTER PANEL	STEEL	24.2	HRP	12.1
ROOF RAIL, BOW, & SUPPORT	STEEL	10.8	HRP	4.3
DASH PANEL	STEEL	12.4	HRP	6.2
DASH PANEL FRAME	STEEL	7.9	HRP	3.2
COWL TOP & SIDE PANEL	STEEL	19.7	HRP	9.9
COWL SUPPORT & FRAME	STEEL	14.9	HRP	6.0
BODY FRONT PILLAR & SUPPORT	HSS	10.7	HRP	5.4
FLOOR PAN	STEEL	59.7	HRP	29.9
SPARE TIRE WELL	STEEL	10.1	HRP	5.1
FLOOR PAN CROSSMEMBER	STEEL	10.4	HRP	4.2
SIDE RAIL & SILL	STEEL	27.3	HRP	10.9
UNDER BODY BRACKET & BRACE	STEEL	19.2	HRP	7.7
INSTRUMENT PANEL COVER	STEEL	2.9	HRP	1.5
FRONT FRAME	HSS	53.9	HRP	27.0
CROSSMEMBER & STRUT	STEEL	21.2	HRP	8.5
FRONT TOWER	STEEL	5.1	HRP	2.0
TOWER REINFORCEMENT	HSS	4.1	HRP	2.1
BATTERY TRAY	STEEL	3.0	HRP	1.5
FRONT SEAT TRACK	STEEL	9.9	HRP	4.0
FRONT SEAT FRAME	STEEL	29.4	HRP	11.8
REAR SEAT FRAME	STEEL	14.1	HRP	5.6
REAR SEAT PIN & BRACKET	STEEL	1.2	HRP	0.5
FRONT BUMPER	ALUM	8.6	HRP	6.9
REAR BUMPER	ALUM	8.3	HRP	6.6
FRONT COIL SPRING	STEEL	16.9	HRP	6.8
FRONT CONTROL ARM	STEEL	8.2	HRP	3.3
SWAYBAR	STEEL	10.1	HRP	4.0
REAR COIL SPRING	STEEL	8.7	HRP	3.5

TABLE A-4 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
REAR CONTROL ARM	STEEL	16.9*	HRP	6.8
REAR SUSPENSION "X" MEMBER	HSS	20.0*	HRP	10.0
ENGINE BLOCK	IRON	71.9	ALUM	36.0
CYLINDER HEAD	ALUM	17.7	ALUM	17.7
CONNECTING ROD	STEEL	5.0	HRP	2.0
VALVE COVER	STEEL	1.9	HRP	1.0
OIL PAN	STEEL	5.9	HRP	3.0
AIR CLEANER	STEEL	3.5*	HRP	1.8
INTAKE MANIFOLD	ALUM	3.2	ALUM	3.2
EXHAUST MANIFOLD	IRON	8.2	STAINLESS STEEL	3.1
ENGINE MOUNT	STEEL	6.6*	HRP	2.6
CLUTCH DUST COVER	STEEL	1.0	HRP	0.5
FUEL TANK	TERNE	14.0	HDPE	9.1
FRONT BRAKE DISC	IRON	14.2	ALUM	7.1
FRONT BRAKE SPLASH SHIELD	STEEL	0.8	HRP	0.4
REAR BRAKE DRUM	IRON	21.4	ALUM	10.7
BRAKE PEDAL	HSS	2.9	HRP	1.5
PARKING BRAKE LEVEL	STEEL	2.8	HRP	1.1
GEAR SHIFT BRACKET	HSS	2.1	HRP	1.1
WHEEL	STEEL	81.3	HRP	32.5
MISC. BRACKET & SUPPORT	STEEL	14.3	HRP	5.7

*ESTIMATED.

TABLE A-5 1978 FORD FAIRMONT 4-DOOR SEDAN EQUIPPED WITH 140 CID ENGINE, HSS DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
FRONT FENDER	STEEL	31.0	HSS	25.7
HOOD OUTER PANEL	STEEL	20.8	HSS	17.3
HOOD INNER PANEL	STEEL	12.3	HSS	10.2
HOOD HINGE & LATCH	STEEL	4.9	HSS	3.9
FRONT DOOR OUTER PANEL	STEEL	23.5	HSS	19.5
FRONT DOOR INNER PANEL	STEEL	37.0	HSS	30.7
FRONT DOOR HINGE & REGULATOR	STEEL	11.8	HSS	9.4
FRONT DOOR GUARD BEAM	HSS	12.5	HSS	12.5
FRONT DOOR LATCH, GUIDE, ETC.	STEEL	8.0*	HSS	6.4
REAR DOOR OUTER PANEL	STEEL	15.5	HSS	12.9
REAR DOOR INNER PANEL	STEEL	31.0	HSS	25.7
REAR DOOR HINGE & REGULATOR	STEEL	10.2	HSS	8.2
REAR DOOR GUARD BEAM	HSS	7.5	HSS	7.5
REAR DOOR LATCH, POST, ETC.	STEEL	7.4*	HSS	5.9
DECK LID OUTER PANEL	STEEL	20.5	HSS	17.0
DECK LID INNER PANEL	STEEL	13.8	HSS	11.5
DECK LID LATCH	STEEL	1.2	HSS	1.0
FRONT CROSSMEMBER	STEEL	53.5	HSS	42.8
REAR CROSSMEMBER	HSS	3.9	HSS	3.9
REMAINING BODY	STEEL	520.5	HSS	439.2
FRONT SEAT TRACK	STEEL	12.0	HSS	9.6
FRONT SEAT BASE	STEEL	15.2	HSS	12.2
FRONT SEAT BACK	STEEL	18.2	HSS	14.2
REAR SEAT BACK	STEEL	6.0*	HSS	4.8
FRONT COIL SPRING	STEEL	20.0	HRP	8.0
FRONT CONTROL ARM	STEEL	35.0*	HSS	28.0
SWAYBAR & MOUNT	STEEL	10.5	HSS	8.4
REAR COIL SPRING	STEEL	14.1	HRP	5.6

TABLE A-5 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
REAR CONTROL ARM	STEEL	17.3	HSS	13.8
DRIVE SHAFT	STEEL	19.5	HRP	7.8
BRAKE PEDAL	STEEL	9.0	HSS	7.2
FRONT BRAKE DISC	IRON	32.5	ALUM	16.3
REAR BRAKE DRUM	IRON	20.9	ALUM	10.5
REAR BRAKE BACKING PLATE	STEEL	5.5*	HSS	4.4
PARKING BRAKE PEDAL	STEEL	3.9	HSS	3.1
MASTER CYLINDER	IRON	6.5	ALUM	3.3
ENGINE BLOCK	IRON	98.4*	IRON	98.4
CYLINDER HEAD	IRON	52.8	ALUM	26.4
INTAKE MANIFOLD	IRON	20.8*	ALUM	10.4
EXHAUST MANIFOLD	IRON	18.0*	STAINLESS STEEL	6.8
WATER PUMP	IRON	8.0*	ALUM	4.0
CONNECTING ROD	STEEL	4.6*	STEEL	4.6
VALVE COVER	STEEL	6.7*	HSS	5.6
ENGINE MOUNT	STEEL	5.0*	HSS	4.0
OIL PAN	STEEL	6.0*	HSS	5.0
CLUTCH DUST COVER	STEEL	11.6	HSS	9.6
FUEL TANK	TERNE	23.4	HDPE	15.2
WHEEL	STEEL	92.5*	ALUM	46.3
RADIATOR	COPPER	9.8	ALUM	4.9
RADIATOR INTAKE SHROUD	STEEL	3.7	HSS	3.1
HEATER CORE	COPPER	3.0*	ALUM	1.5
FRONT BUMPER	ALUM & STEEL	45.6	FOAM	23.8
REAR BUMPER	ALUM & STEEL	33.4	FOAM	23.8
MISC. BRACKET & SUPPORT	STEEL	15.0	HSS	12.0

*ESTIMATED.

TABLE A-6 1978 FORD FAIRMONT 4-DOOR SEDAN EQUIPPED WITH 140 CID ENGINE, FRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
FRONT FENDER	STEEL	31.0	FRP	24.2
HOOD OUTER PANEL	STEEL	20.8	FRP	16.2
HOOD INNER PANEL	STEEL	12.3	FRP	9.6
HOOD HINGE & LATCH	STEEL	4.9	HSS	3.9
FRONT DOOR OUTER PANEL	STEEL	23.5	FRP	18.3
FRONT DOOR INNER PANEL	STEEL	37.0	FRP	28.9
FRONT DOOR HINGE & REGULATOR	STEEL	11.8	HSS	9.4
FRONT DOOR GUARD BEAM	HSS	12.5	HSS	12.5
FRONT DOOR LATCH, GUIDE, ETC.	STEEL	8.0*	HSS	6.4
REAR DOOR OUTER PANEL	STEEL	15.5	FRP	12.1
REAR DOOR INNER PANEL	STEEL	31.0	FRP	24.2
REAR DOOR HINGE & REGULATOR	STEEL	10.2	HSS	8.2
REAR DOOR GUARD BEAM	HSS	7.5	HSS	7.5
REAR DOOR LATCH, POST, ETC.	STEEL	7.4*	HSS	5.9
DECK LID OUTER PANEL	STEEL	20.5	FRP	16.0
DECK LID INNER PANEL	STEEL	13.8	FRP	10.8
DECK LID LATCH	STEEL	1.2	HSS	1.0
FRONT CROSSMEMBER	STEEL	53.5	HSS	42.8
REAR CROSSMEMBER	HSS	3.9	HSS	3.9
REMAINING BODY	STEEL	520.5	HSS	439.2
FRONT SEAT TRACK	STEEL	12.0	HSS	9.6
FRONT SEAT BASE	STEEL	15.2	HSS	12.2
FRONT SEAT BACK	STEEL	18.2	HSS	14.2
REAR SEAT BACK	STEEL	6.0*	HSS	4.8
FRONT COIL SPRING	STEEL	20.0	HRP	8.0
FRONT CONTROL ARM	STEEL	35.0*	HSS	28.0
SWAYBAR & MOUNT	STEEL	10.5	HSS	8.4
REAR COIL SPRING	STEEL	14.1	HRP	5.6

TABLE A-6 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
REAR CONTROL ARM	STEEL	17.3	HSS	13.8
DRIVE SHAFT	STEEL	19.5	HRP	7.8
BRAKE PEDAL	STEEL	9.0	HSS	7.2
FRONT BRAKE DISC	IRON	32.5	ALUM	16.3
REAR BRAKE DRUM	IRON	20.9	ALUM	10.5
REAR BRAKE BACKING PLATE	STEEL	5.5*	HSS	4.4
PARKING BRAKE PEDAL	STEEL	3.9	HSS	3.1
MASTER CYLINDER	IRON	6.5	ALUM	3.3
ENGINE BLOCK	IRON	98.4*	IRON	98.4
CYLINDER HEAD	IRON	52.8	ALUM	26.4
INTAKE MANIFOLD	IRON	20.8*	ALUM	10.4
EXHAUST MANIFOLD	IRON	18.0*	STAINLESS STEEL	6.8
WATER PUMP	IRON	8.0*	ALUM	4.0
CONNECTING ROD	STEEL	4.6*	STEEL	4.6
VALVE COVER	STEEL	6.7*	FRP	5.2
ENGINE MOUNT	STEEL	5.0*	HSS	4.0
OIL PAN	STEEL	6.0*	FRP	4.7
CLUTCH DUST COVER	STEEL	11.6	FRP	9.0
FUEL TANK	TERNE	23.4	HDPE	15.2
WHEEL	STEEL	92.5*	HRP	37.0
RADIATOR	COPPER	9.8	ALUM	4.9
RADIATOR INTAKE SHROUD	STEEL	3.7	FRP	2.9
HEATER CORE	COPPER	3.0*	ALUM	1.5
FRONT BUMPER	ALUM & STEEL	45.6	FOAM	23.8
REAR BUMPER	ALUM & STEEL	33.4	FOAM	23.8
MISC. BRACKET & SUPPORT	STEEL	15.0	HSS	12.0

*ESTIMATED.

TABLE A-7 1978 FORD FAIRMONT 4-DOOR SEDAN EQUIPPED WITH 140 CID ENGINE, ALUMINUM DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
FRONT FENDER	STEEL	31.0	ALUM	18.0
HOOD OUTER PANEL	STEEL	20.8	ALUM	12.1
HOOD INNER PANEL	STEEL	12.3	ALUM	7.1
HOOD HINGE & LATCH	STEEL	4.9	HSS	3.9
FRONT DOOR OUTER PANEL	STEEL	23.5	ALUM	13.6
FRONT DOOR INNER PANEL	STEEL	37.0	ALUM	21.5
FRONT DOOR HINGE & REGULATOR	STEEL	11.8	HSS	9.4
FRONT DOOR GUARD BEAM	HSS	12.5	HSS	12.5
FRONT DOOR LATCH, GUIDE, ETC.	STEEL	8.0*	HSS	6.4
REAR DOOR OUTER PANEL	STEEL	15.5	ALUM	9.0
REAR DOOR INNER PANEL	STEEL	31.0	ALUM	18.0
REAR DOOR HINGE & REGULATOR	STEEL	10.2	HSS	8.2
REAR DOOR GUARD BEAM	HSS	7.5	HSS	7.5
REAR DOOR LATCH, POST, ETC.	STEEL	7.4*	HSS	5.9
DECK LID OUTER PANEL	STEEL	20.5	ALUM	11.9
DECK LID INNER PANEL	STEEL	13.8	ALUM	8.0
DECK LID LATCH	STEEL	1.2	HSS	1.0
FRONT CROSSMEMBER	STEEL	53.5	HSS	42.8
REAR CROSSMEMBER	HSS	3.9	HSS	3.9
REMAINING BODY	STEEL	520.5	HSS	439.2
FRONT SEAT TRACK	STEEL	12.0	HSS	9.6
FRONT SEAT BASE	STEEL	15.2	HSS	12.2
FRONT SEAT BACK	STEEL	18.2	HSS	14.2
REAR SEAT BACK	STEEL	6.0*	HSS	4.8
FRONT COIL SPRING	STEEL	20.0	HRP	8.0
FRONT CONTROL ARM	STEEL	35.0*	HSS	28.0
SWAYBAR & MOUNT	STEEL	10.5	HSS	8.4
REAR COIL SPRING	STEEL	14.1	HRP	5.6

TABLE A-7 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
REAR CONTROL ARM	STEEL	17.3	HSS	13.8
DRIVE SHAFT	STEEL	19.5	HRP	7.8
BRAKE PEDAL	STEEL	9.0	HSS	7.2
FRONT BRAKE DISC	IRON	32.5	ALUM	16.3
REAR BRAKE DRUM	IRON	20.9	ALUM	10.5
REAR BRAKE BACKING PLATE	STEEL	5.5*	HSS	4.4
PARKING BRAKE PEDAL	STEEL	3.9	HSS	3.1
MASTER CYLINDER	IRON	6.5	ALUM	3.3
ENGINE BLOCK	IRON	98.4*	ALUM	49.2
CYLINDER HEAD	IRON	52.8	ALUM	26.4
INTAKE MANIFOLD	IRON	20.8*	ALUM	10.4
EXHAUST MANIFOLD	IRON	18.0*	STAINLESS STEEL	6.8
WATER PUMP	IRON	8.0*	ALUM	4.0
CONNECTING ROD	STEEL	4.6*	STEEL	4.6
VALVE COVER	STEEL	6.7*	ALUM	3.9
ENGINE MOUNT	STEEL	5.0*	HSS	4.0
OIL PAN	STEEL	6.0*	ALUM	3.5
CLUTCH DUST COVER	STEEL	11.6	ALUM	6.7
FUEL TANK	TERNE	23.4	HDPE	15.2
WHEEL	STEEL	92.5*	ALUM	46.3
RADIATOR	COPPER	9.8	ALUM	4.9
RADIATOR INTAKE SHROUD	STEEL	3.7	ALUM	2.1
HEATER CORE	COPPER	3.0*	ALUM	1.5
FRONT BUMPER	ALUM & STEEL	45.6	FOAM	23.8
REAR BUMPER	ALUM & STEEL	33.4	FOAM	23.8
MISC. BRACKET & SUPPORT	STEEL	15.0	HSS	12.0

*ESTIMATED.

TABLE A-8 1978 FORD FAIRMONT 4-DOOR SEDAN EQUIPPED WITH 140 CID ENGINE, HRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
FRONT FENDER	STEEL	31.0	HRP	15.5
HOOD OUTER PANEL	STEEL	20.8	HRP	10.4
HOOD INNER PANEL	STEEL	12.3	HRP	6.2
HOOD HINGE & LATCH	STEEL	4.9	HRP	2.0
FRONT DOOR OUTER PANEL	STEEL	23.5	HRP	11.8
FRONT DOOR INNER PANEL	STEEL	37.0	HRP	18.5
FRONT DOOR HINGE & REGULATOR	STEEL	11.8	HRP	4.7
FRONT DOOR GUARD BEAM	HSS	12.5	HRP	6.3
FRONT DOOR LATCH, GUIDE, ETC.	STEEL	8.0*	HRP	3.2
REAR DOOR OUTER PANEL	STEEL	15.5	HRP	7.8
REAR DOOR INNER PANEL	STEEL	31.0	HRP	15.5
REAR DOOR HINGE & REGULATOR	STEEL	10.2	HRP	4.1
REAR DOOR GUARD BEAM	HSS	7.5	HRP	3.8
REAR DOOR LATCH, POST, ETC.	STEEL	7.4*	HRP	3.0
DECK LID OUTER PANEL	STEEL	20.5	HRP	10.3
DECK LID INNER PANEL	STEEL	13.8	HRP	6.9
DECK LID LATCH	STEEL	1.2	HRP	0.5
FRONT CROSSMEMBER	STEEL	53.5	HRP	21.4
REAR CROSSMEMBER	HSS	3.9	HRP	2.0
REMAINING BODY	STEEL	520.5	HRP	219.6
FRONT SEAT TRACK	STEEL	12.0	HRP	4.8
FRONT SEAT BASE	STEEL	15.2	HRP	6.1
FRONT SEAT BACK	STEEL	18.2	HRP	7.3
REAR SEAT BACK	STEEL	6.0*	HRP	2.4
FRONT COIL SPRING	STEEL	20.0	HRP	8.0
FRONT CONTROL ARM	STEEL	35.0*	HRP	14.0
SWAYBAR & MOUNT	STEEL	10.5	HRP	4.2
REAR COIL SPRING	STEEL	14.1	HRP	5.6

TABLE A-8 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
REAR CONTROL ARM	STEEL	17.3	HRP	6.9
DRIVE SHAFT	STEEL	19.5	HRP	7.8
BRAKE PEDAL	STEEL	9.0	HSS	7.2
FRONT BRAKE DISC	IRON	32.5	ALUM	16.3
REAR BRAKE DRUM	IRON	20.9	ALUM	10.5
REAR BRAKE BACKING PLATE	STEEL	5.5*	HRP	2.2
PARKING BRAKE PEDAL	STEEL	3.9	HRP	1.6
MASTER CYLINDER	IRON	6.5	ALUM	3.3
ENGINE BLOCK	IRON	98.4*	ALUM	49.2
CYLINDER HEAD	IRON	52.8	ALUM	26.4
INTAKE MANIFOLD	IRON	20.8*	ALUM	10.4
EXHAUST MANIFOLD	IRON	18.0*	STAINLESS STEEL	6.8
WATER PUMP	IRON	8.0*	ALUM	4.0
CONNECTING ROD	STEEL	4.6*	HRP	1.8
VALVE COVER	STEEL	6.7*	HRP	3.4
ENGINE MOUNT	STEEL	5.0*	HRP	2.0
OIL PAN	STEEL	6.0*	HRP	3.0
CLUTCH DUST COVER	STEEL	11.6	HRP	5.8
FUEL TANK	TERNE	23.4	HDPE	15.2
WHEEL	STEEL	92.5*	HRP	37.0
RADIATOR	COPPER	9.8	ALUM	4.9
RADIATOR INTAKE SHROUD	STEEL	3.7	HRP	1.9
HEATER CORE	COPPER	3.0*	ALUM	1.5
FRONT BUMPER	ALUM & STEEL	45.6	FOAM	23.8
REAR BUMPER	ALUM & STEEL	33.4	FOAM	23.8
MISC. BRACKET & SUPPORT	STEEL	15.0	HRP	6.0
PUSH ROD	STEEL	1.1	HRP	0.4

*ESTIMATED.

TABLE A-9 1977 CHEVROLET IMPALA 4-DOOR SEDAN
EQUIPPED WITH 305 CID ENGINE,
HSS DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
FRONT FENDER OUTER PANEL	STEEL	31.0	HSS	25.7
FRONT FENDER INNER PANEL	STEEL	24.0	HSS	19.9
FRONT WHEEL HOUSING	STEEL	23.0	HSS	19.1
HOOD OUTER PANEL	STEEL	32.5	HSS	27.0
HOOD INNER PANEL	STEEL	20.0	HSS	16.6
HOOD HINGE	STEEL	12.0	HSS	9.6
RADIATOR SUPPORT	STEEL	26.5	HSS	21.2
FRONT DOOR OUTER PANEL	STEEL	24.0	HSS	19.9
FRONT DOOR INNER PANEL	STEEL	39.0	HSS	32.4
FRONT DOOR GUARD BEAM	STEEL	17.0	HSS	13.6
FRONT DOOR HINGE & LATCH PLATE	STEEL	23.4	HSS	18.7
REAR DOOR OUTER PANEL	STEEL	9.0	HSS	7.5
REAR DOOR INNER PANEL	STEEL	36.0	HSS	29.9
REAR DOOR GUARD BEAM	STEEL	11.0	HSS	8.8
DECK LID OUTER PANEL	STEEL	28.5	HSS	23.7
DECK LID INNER PANEL	STEEL	13.5	HSS	11.2
DECK LID HINGE	STEEL	6.0	HSS	4.8
QUARTER PANEL & WHEEL WELL	STEEL	72.0	HSS	59.8
TAIL LIGHT PANEL	STEEL	11.5	HSS	9.5
FIREWALL	STEEL	51.5	HSS	42.7
ROOF OUTER PANEL	STEEL	35.0	HSS	29.1
ROOF INNER PANEL	STEEL	25.5	HSS	21.2
FRAME	STEEL	261.0	HSS	208.8
SILL	STEEL	55.0	HSS	44.0
A POST	STEEL	45.0	HSS	36.0
B POST	STEEL	25.0	HSS	20.0
C POST	STEEL	18.0	HSS	14.4

TABLE A-9 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
FLOOR PANEL	STEEL	106.0	HSS	88.0
REAR SHELF	STEEL	17.0	HSS	14.1
LOWER INSTRUMENT PANEL	STEEL	5.5	HSS	4.6
BATTERY TRAY	STEEL	2.4	HSS	2.0
WINDOW CHANNEL, RAIL & FRAME	STEEL	10.4	HSS	8.3
WINDOW CONTROL MECHANISM	STEEL	13.5	HSS	10.8
FRONT SEAT TRACK	STEEL	8.5	HSS	6.8
FRONT SEAT FRAME	STEEL	34.5	HSS	27.6
FRONT SEAT BACK	STEEL	10.5	HSS	8.7
REAR SEAT FRAME	STEEL	9.5	HSS	7.6
REAR SEAT BACK	STEEL	11.0	HSS	9.1
FRONT BUMPER & ENERGY ABSORBER	VARIOUS	73.5	FOAM	27.0
REAR BUMPER & ENERGY ABSORBER	VARIOUS	70.9	FOAM	27.0
FRONT COIL SPRING	STEEL	25.0	HRP	10.0
FRONT CONTROL ARM	STEEL	35.6	HSS	28.5
SWAY BAR & TIE ROD	STEEL	22.0	HSS	17.6
REAR LEAF SPRING	STEEL	15.0	HRP	6.0
REAR CONTROL ARM	STEEL	13.0	HSS	10.4
DRIVE SHAFT	STEEL	18.1	HRP	7.2
FRONT BRAKE DISC	IRON	44.5	ALUM	22.3
FRONT BRAKE PEDAL & SUPPORT	STEEL	3.7	HSS	3.0
REAR BRAKE DRUM	IRON	29.5	ALUM	14.8
REAR BRAKE BACKING PLATE	STEEL	6.4	HSS	5.1
MASTER CYLINDER	IRON	7.1	ALUM	3.6
ENGINE BLOCK	IRON	158.7*	IRON	158.7
CYLINDER HEAD	IRON	83.2*	ALUM	41.6
INTAKE MANIFOLD	IRON	39.7*	ALUM	19.9

TABLE A-9 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
EXHAUST MANIFOLD	IRON	31.0	STAINLESS STEEL	11.6
WATER PUMP	IRON	12.2	ALUM	6.1
CONNECTING ROD	STEEL	11.6*	STEEL	11.6
VALVE COVER	STEEL	4.4	HSS	3.7
AIR CLEANER	STEEL	5.5	HSS	4.6
OIL PAN	STEEL	6.5	HSS	5.4
ENGINE MOUNT	STEEL	9.6	HSS	7.7
ENGINE #1 CROSSMEMBER	STEEL	18.6	HSS	14.9
ENGINE #2 CROSSMEMBER	STEEL	2.9	HSS	2.3
RADIATOR	COPPER	15.0	ALUM	7.5
HEATER CORE	COPPER	3.3	ALUM	1.7
FUEL TANK	TERNE	26.7	HDPE	17.4
TRANSMISSION FLUID PAN	STEEL	2.5	HSS	2.1
WHEEL	STEEL	107.0	ALUM	53.5
MISC. BRACKET & SUPPORT	STEEL	20.0*	HSS	16.0

*ESTIMATED.

TABLE A-10 1977 CHEVROLET IMPALA 4-DOOR SEDAN EQUIPPED WITH 305 CID ENGINE, FRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
FRONT FENDER OUTER PANEL	STEEL	31.0	FRP	24.2
FRONT FENDER INNER PANEL	STEEL	24.0	FRP	18.7
FRONT WHEEL HOUSING	STEEL	23.0	FRP	17.9
HOOD OUTER PANEL	STEEL	32.5	FRP	25.4
HOOD INNER PANEL	STEEL	20.0	FRP	15.6
HOOD HINGE	STEEL	12.0	HSS	9.6
RADIATOR SUPPORT	STEEL	26.5	HSS	21.2
FRONT DOOR OUTER PANEL	STEEL	24.0	FRP	18.7
FRONT DOOR INNER PANEL	STEEL	39.0	FRP	30.4
FRONT DOOR GUARD BEAM	STEEL	17.0	HSS	13.6
FRONT DOOR HINGE & LATCH PLATE	STEEL	23.4	HSS	18.7
REAR DOOR OUTER PANEL	STEEL	9.0	FRP	7.0
REAR DOOR INNER PANEL	STEEL	36.0	FRP	28.1
REAR DOOR GUARD BEAM	STEEL	11.0	HSS	8.8
DECK LID OUTER PANEL	STEEL	28.5	FRP	22.2
DECK LID INNER PANEL	STEEL	13.5	FRP	10.5
DECK LID HINGE	STEEL	6.0	HSS	4.8
QUARTER PANEL & WHEEL WELL	STEEL	72.0	FRP	56.2
TAIL LIGHT PANEL	STEEL	11.5	FRP	9.0
FIREWALL	STEEL	51.5	FRP	40.2
ROOF OUTER PANEL	STEEL	35.0	FRP	27.3
ROOF INNER PANEL	STEEL	25.5	FRP	19.9
FRAME	STEEL	261.0	HSS	208.8
SILL	STEEL	55.0	HSS	44.0
A POST	STEEL	45.0	HSS	36.0
B POST	STEEL	25.0	HSS	20.0
C POST	STEEL	18.0	HSS	14.4

TABLE A-10 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
FLOOR PANEL	STEEL	106.0	FRP	82.7
REAR SHELF	STEEL	17.0	FRP	13.3
LOWER INSTRUMENT PANEL	STEEL	5.5	FRP	4.3
BATTERY TRAY	STEEL	2.4	FRP	1.9
WINDOW CHANNEL, RAIL & FRAME	STEEL	10.4	HSS	8.3
WINDOW CONTROL MECHANISM	STEEL	13.5	HSS	10.8
FRONT SEAT TRACK	STEEL	8.5	HSS	6.8
FRONT SEAT FRAME	STEEL	34.5	HSS	27.6
FRONT SEAT BACK	STEEL	10.5	FRP	8.2
REAR SEAT FRAME	STEEL	9.5	HSS	7.6
REAR SEAT BACK	STEEL	11.0	FRP	8.6
FRONT BUMPER & ENERGY ABSORBER	VARIOUS	73.5	FOAM	27.0
REAR BUMPER & ENERGY ABSORBER	VARIOUS	70.9	FOAM	27.0
FRONT COIL SPRING	STEEL	25.0	HRP	10.0
FRONT CONTROL ARM	STEEL	35.6	HSS	28.5
SWAY BAR & TIE ROD	STEEL	22.0	HSS	17.6
REAR LEAF SPRING	STEEL	15.0	HRP	6.0
REAR CONTROL ARM	STEEL	13.0	HSS	10.4
DRIVE SHAFT	STEEL	18.1	HRP	7.2
FRONT BRAKE DISC	IRON	44.5	ALUM	22.3
FRONT BRAKE PEDAL & SUPPORT	STEEL	3.7	HSS	3.0
REAR BRAKE DRUM	IRON	29.5	ALUM	14.8
REAR BRAKE BACKING PLATE	STEEL	6.4	HSS	5.1
MASTER CYLINDER	IRON	7.1	ALUM	3.6
ENGINE BLOCK	IRON	158.7*	IRON	158.7
CYLINDER HEAD	IRON	83.2*	ALUM	41.6
INTAKE MANIFOLD	IRON	39.7*	ALUM	19.9

TABLE A-10 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
EXHAUST MANIFOLD	IRON	31.0	STAINLESS STEEL	11.6
WATER PUMP	IRON	12.2	ALUM	6.1
CONNECTING ROD	STEEL	11.6*	STEEL	11.6
VALVE COVER	STEEL	4.4	FRP	3.4
AIR CLEANER	STEEL	5.5	FRP	4.3
OIL PAN	STEEL	6.5	FRP	5.1
ENGINE MOUNT	STEEL	9.6	HSS	7.7
ENGINE #1 CROSSMEMBER	STEEL	18.6	HSS	14.9
ENGINE #2 CROSSMEMBER	STEEL	2.9	HSS	2.3
RADIATOR	COPPER	15.0	ALUM	7.5
HEATER CORE	COPPER	3.3	ALUM	1.7
FUEL TANK	TERNE	26.7	HDPE	17.4
TRANSMISSION FLUID PAN	STEEL	2.5	FRP	2.0
WHEEL	STEEL	107.0	HRP	42.8
MISC. BRACKET & SUPPORT	STEEL	20.0*	HSS	16.0

*ESTIMATED.

TABLE A-11 1977 CHEVROLET IMPALA 4-DOOR SEDAN EQUIPPED WITH 305 CID ENGINE, ALUMINUM DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
FRONT FENDER OUTER PANEL	STEEL	31.0	ALUM	18.0
FRONT FENDER INNER PANEL	STEEL	24.0	ALUM	13.9
FRONT WHEEL HOUSING	STEEL	23.0	ALUM	13.3
HOOD OUTER PANEL	STEEL	32.5	ALUM	18.9
HOOD INNER PANEL	STEEL	20.0	ALUM	11.6
HOOD HINGE	STEEL	12.0	HSS	9.6
RADIATOR SUPPORT	STEEL	26.5	HSS	21.2
FRONT DOOR OUTER PANEL	STEEL	24.0	ALUM	13.9
FRONT DOOR INNER PANEL	STEEL	39.0	ALUM	22.6
FRONT DOOR GUARD BEAM	STEEL	17.0	HSS	13.6
FRONT DOOR HINGE & LATCH PLATE	STEEL	23.4	HSS	18.7
REAR DOOR OUTER PANEL	STEEL	9.0	ALUM	5.2
REAR DOOR INNER PANEL	STEEL	36.0	ALUM	20.9
REAR DOOR GUARD BEAM	STEEL	11.0	HSS	8.8
DECK LID OUTER PANEL	STEEL	28.5	ALUM	16.5
DECK LID INNER PANEL	STEEL	13.5	ALUM	7.8
DECK LID HINGE	STEEL	6.0	HSS	4.8
QUARTER PANEL & WHEEL WELL	STEEL	72.0	ALUM	41.8
TAIL LIGHT PANEL	STEEL	11.5	ALUM	6.7
FIREWALL	STEEL	51.5	ALUM	29.9
ROOF OUTER PANEL	STEEL	35.0	ALUM	20.3
ROOF INNER PANEL	STEEL	25.5	ALUM	14.8
FRAME	STEEL	261.0	HSS	208.8
SILL	STEEL	55.0	HSS	44.0
A POST	STEEL	45.0	HSS	36.0
B POST	STEEL	25.0	HSS	20.0
C POST	STEEL	18.0	HSS	14.4

TABLE A-11 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
FLOOR PANEL	STEEL	106.0	ALUM	61.5
REAR SHELF	STEEL	17.0	ALUM	9.9
LOWER INSTRUMENT PANEL	STEEL	5.5	ALUM	3.2
BATTERY TRAY	STEEL	2.4	ALUM	1.4
WINDOW CHANNEL, RAIL & FRAME	STEEL	10.4	HSS	8.3
WINDOW CONTROL MECHANISM	STEEL	13.5	HSS	10.8
FRONT SEAT TRACK	STEEL	8.5	HSS	6.8
FRONT SEAT FRAME	STEEL	34.5	HSS	27.6
FRONT SEAT BACK	STEEL	10.5	ALUM	6.1
REAR SEAT FRAME	STEEL	9.5	HSS	7.6
REAR SEAT BACK	STEEL	11.0	ALUM	6.4
FRONT BUMPER & ENERGY ABSORBER	VARIOUS	73.5	FOAM	27.0
REAR BUMPER & ENERGY ABSORBER	VARIOUS	70.9	FOAM	27.0
FRONT COIL SPRING	STEEL	25.0	HRP	10.0
FRONT CONTROL ARM	STEEL	35.6	HSS	28.5
SWAY BAR & TIE ROD	STEEL	22.0	HSS	17.6
REAR LEAF SPRING	STEEL	15.0	HRP	6.0
REAR CONTROL ARM	STEEL	13.0	HSS	10.4
DRIVE SHAFT	STEEL	18.1	HRP	7.2
FRONT BRAKE DISC	IRON	44.5	ALUM	22.3
FRONT BRAKE PEDAL & SUPPORT	STEEL	3.7	HSS	3.0
REAR BRAKE DRUM	IRON	29.5	ALUM	14.8
REAR BRAKE BACKING PLATE	STEEL	6.4	HSS	5.1
MASTER CYLINDER	IRON	7.1	ALUM	3.6
ENGINE BLOCK	IRON	158.7*	ALUM	79.4
CYLINDER HEAD	IRON	83.2*	ALUM	41.6
INTAKE MANIFOLD	IRON	39.7*	ALUM	19.9

TABLE A-11 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
EXHAUST MANIFOLD	IRON	31.0	STAINLESS STEEL	11.6
WATER PUMP	IRON	12.2	ALUM	6.1
CONNECTING ROD	STEEL	11.6*	STEEL	11.6
VALVE COVER	STEEL	4.4	ALUM	2.6
AIR CLEANER	STEEL	5.5	ALUM	3.2
OIL PAN	STEEL	6.5	ALUM	3.8
ENGINE MOUNT	STEEL	9.6	HSS	7.7
ENGINE #1 CROSSMEMBER	STEEL	18.6	HSS	14.9
ENGINE #2 CROSSMEMBER	STEEL	2.9	HSS	2.3
RADIATOR	COPPER	15.0	ALUM	7.5
HEATER CORE	COPPER	3.3	ALUM	1.7
FUEL TANK	TERNE	26.7	HDPE	17.4
TRANSMISSION FLUID PAN	STEEL	2.5	ALUM	1.5
WHEEL	STEEL	107.0	ALUM	53.5
MISC. BRACKET & SUPPORT	STEEL	20.0*	HSS	16.0

*ESTIMATED.

TABLE A-12 1977 CHEVROLET IMPALA 4-DOOR SEDAN EQUIPPED WITH 305 CID ENGINE, HRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
FRONT FENDER OUTER PANEL	STEEL	31.0	HRP	15.5
FRONT FENDER INNER PANEL	STEEL	24.0	HRP	12.0
FRONT WHEEL HOUSING	STEEL	23.0	HRP	11.5
HOOD OUTER PANEL	STEEL	32.5	HRP	16.3
HOOD INNER PANEL	STEEL	20.0	HRP	10.0
HOOD HINGE	STEEL	12.0	HRP	4.8
RADIATOR SUPPORT	STEEL	26.5	HRP	10.6
FRONT DOOR OUTER PANEL	STEEL	24.0	HRP	12.0
FRONT DOOR INNER PANEL	STEEL	39.0	HRP	19.5
FRONT DOOR GUARD BEAM	STEEL	17.0	HRP	6.8
FRONT DOOR HINGE & LATCH PLATE	STEEL	23.4	HRP	9.4
REAR DOOR OUTER PANEL	STEEL	9.0	HRP	4.5
REAR DOOR INNER PANEL	STEEL	36.0	HRP	18.0
REAR DOOR GUARD BEAM	STEEL	11.0	HRP	4.4
DECK LID OUTER PANEL	STEEL	28.5	HRP	14.3
DECK LID INNER PANEL	STEEL	13.5	HRP	6.8
DECK LID HINGE	STEEL	6.0	HRP	2.4
QUARTER PANEL & WHEEL WELL	STEEL	72.0	HRP	36.0
TAIL LIGHT PANEL	STEEL	11.5	HRP	5.8
FIREWALL	STEEL	51.5	HRP	25.8
ROOF OUTER PANEL	STEEL	35.0	HRP	17.5
ROOF INNER PANEL	STEEL	25.5	HRP	12.8
FRAME	STEEL	261.0	HRP	104.4
SILL	STEEL	55.0	HRP	22.0
A POST	STEEL	45.0	HRP	18.0
B POST	STEEL	25.0	HRP	10.0
C POST	STEEL	18.0	HRP	7.2

TABLE A-12 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
FLOOR PANEL	STEEL	106.0	HRP	53.0
REAR SHELF	STEEL	17.0	HRP	8.5
LOWER INSTRUMENT PANEL	STEEL	5.5	HRP	2.8
BATTERY TRAY	STEEL	2.4	HRP	1.2
WINDOW CHANNEL, RAIL & FRAME	STEEL	10.4	HRP	4.2
WINDOW CONTROL MECHANISM	STEEL	13.5	HRP	5.4
FRONT SEAT TRACK	STEEL	8.5	HRP	3.4
FRONT SEAT FRAME	STEEL	34.5	HRP	13.8
FRONT SEAT BACK	STEEL	10.5	HRP	5.3
REAR SEAT FRAME	STEEL	9.5	HRP	3.8
REAR SEAT BACK	STEEL	11.0	HRP	5.5
FRONT BUMPER & ENERGY ABSORBER	VARIOUS	73.5	FOAM	27.0
REAR BUMPER & ENERGY ABSORBER	VARIOUS	70.9	FOAM	27.0
FRONT COIL SPRING	STEEL	25.0	HRP	10.0
FRONT CONTROL ARM	STEEL	35.6	HRP	14.2
SWAY BAR & TIE ROD	STEEL	22.0	HRP	8.8
REAR LEAF SPRING	STEEL	15.0	HRP	6.0
REAR CONTROL ARM	STEEL	13.0	HRP	5.2
DRIVE SHAFT	STEEL	18.1	HRP	7.2
FRONT BRAKE DISC	IRON	44.5	ALUM	22.3
FRONT BRAKE PEDAL & SUPPORT	STEEL	3.7	HRP	1.5
REAR BRAKE DRUM	IRON	29.5	ALUM	14.8
REAR BRAKE BACKING PLATE	STEEL	6.4	HRP	2.6
MASTER CYLINDER	IRON	7.1	ALUM	3.6
ENGINE BLOCK	IRON	158.7*	ALUM	79.4
CYLINDER HEAD	IRON	83.2*	ALUM	41.6
INTAKE MANIFOLD	IRON	39.7*	ALUM	19.9

TABLE A-12 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
EXHAUST MANIFOLD	IRON	31.0	STAINLESS STEEL	11.6
WATER PUMP	IRON	12.2	ALUM	6.1
CONNECTING ROD	STEEL	11.6*	HRP	4.6
VALVE COVER	STEEL	4.4	HRP	2.2
AIR CLEANER	STEEL	5.5	HRP	2.8
OIL PAN	STEEL	6.5	HRP	3.3
ENGINE MOUNT	STEEL	9.6	HRP	3.8
ENGINE #1 CROSSMEMBER	STEEL	18.6	HRP	7.4
ENGINE #2 CROSSMEMBER	STEEL	2.9	HRP	1.2
RADIATOR	COPPER	15.0	ALUM	7.5
HEATER CORE	COPPER	3.3	ALUM	1.7
FUEL TANK	TERNE	26.7	HDPE	17.4
TRANSMISSION FLUID PAN	STEEL	2.5	HRP	1.3
WHEEL	STEEL	107.0	HRP	42.8
MISC. BRACKET & SUPPORT	STEEL	20.0*	HRP	8.0

*ESTIMATED.

APPENDIX B
LIGHT TRUCK MATERIAL SUBSTITUTION

This appendix summarizes original material and weight of selected vehicular components and the weight of replacement components for the three baseline light trucks. For each baseline truck four alternative material dominant cases are presented. Tables B1 through B4, B5 through B8, and B9 through B12 tabulate component data for the 1978 D-100 pickup truck, 1978 B-100 van, and 1978 Ramcharger, respectively.

TABLE B-1 1978 DODGE D 100 PICKUP TRUCK EQUIPPED WITH 225 CID ENGINE, HSS DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
HOOD OUTER PANEL	STEEL	34.7	HSS	28.8
HOOD INNER PANEL	STEEL	20.3	HSS	16.8
HOOD HINGE BRACKET	STEEL	10.0	HSS	8.0
RADIATOR SUPPORT	STEEL	40.0	HSS	32.0
GRILLE LOWER PANEL	STEEL	4.0	HSS	3.3
FENDER OUTER PANEL	STEEL	35.1	HSS	29.1
FENDER INNER PANEL	STEEL	16.9	HSS	14.0
FRONT WHEEL HOUSE	STEEL	21.0	HSS	17.4
CAB ROOF	STEEL	52.0	HSS	43.2
CAB REAR PANEL	STEEL	31.5	HSS	26.1
DASH PANEL	STEEL	32.0	HSS	26.6
CAB FLOOR	STEEL	44.0	HSS	36.5
COWL SIDE	STEEL	22.0	HSS	18.3
COWL VENT PANEL	STEEL	4.0	HSS	3.3
DOOR OUTER PANEL	STEEL	40.0	HSS	33.2
DOOR INNER PANEL	STEEL	40.0	HSS	33.2
DOOR REGULATOR	STEEL	8.0	HSS	6.4
SILL	STEEL	17.0	HSS	13.6
SEAT FRAME	STEEL	44.0	HSS	35.2
BOX FLOOR	STEEL	107.8	HSS	89.5
FLOOR SUPPORT CHANNEL	STEEL	55.0	HSS	44.0
BOX FRONT PANEL	STEEL	22.0	HSS	18.3
TAILGATE	STEEL	44.0	HSS	36.5
SIDE PANEL OUTER	STEEL	42.8	HSS	35.5
SIDE PANEL INNER	STEEL	60.0	HSS	49.8
REAR WHEEL HOUSE	STEEL	24.0	HSS	19.9
FRAME	STEEL	350.0	HSS	280.0
ENGINE SUPPORT CROSSMEMBER	STEEL	20.5	HSS	16.4

TABLE B-1 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
FRONT BUMPER	STEEL	29.0	FOAM	14.5
BUMPER MOUNTING BRACKET	STEEL	4.0	HSS	3.2
BATTERY TRAY	STEEL	3.0	HSS	2.5
RADIATOR CORE	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
ENGINE MOUNTING BRACKET	STEEL	8.5	HSS	6.8
FRONT SPRING	STEEL	24.0	HRP	9.6
LOWER CONTROL ARM	STEEL	18.0	HSS	14.4
UPPER CONTROL ARM	STEEL	14.5	HSS	11.6
REAR SPRING	STEEL	69.0	HRP	27.6
REAR SPRING SHACKLE	STEEL	3.0	HSS	2.4
REAR AXLE U-BOLT PLATE	STEEL	10.0	HSS	8.0
STEERING GEAR HOUSING	IRON	15.5	ALUM	7.8
MASTER CYLINDER	IRON	10.2	ALUM	5.1
BRAKE AND CLUTCH PEDALS	STEEL	6.0	HSS	4.8
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HSS	3.2
DRIVE SHAFT	STEEL	24.0	HRP	9.6
BRAKE DISC	IRON	55.5	ALUM	27.8
BRAKE DRUM	IRON	26.0	ALUM	13.0
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	IRON	145.0
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	HSS	5.0
VALVE COVER	STEEL	6.5	HSS	5.4
OIL PAN	STEEL	7.5	HSS	6.2
WATER PUMP	IRON	7.5	ALUM	3.7

TABLE B-1 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
CONNECTING ROD	STEEL	10.0	STEEL	10.0
WHEEL	STEEL	107.5	ALUM	53.8
FUEL TANK	TERNE	21.0	HDPE	13.6
WINDSHIELD	GLASS	31.0	GLASS	24.8
DOOR WINDOW	GLASS	16.0	GLASS	10.7
REAR WINDOW	GLASS	13.5	GLASS	9.0

TABLE B-2 1978 DODGE D 100 PICKUP TRUCK EQUIPPED WITH 225 CID ENGINE, FRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
HOOD OUTER PANEL	STEEL	34.7	FRP	27.1
HOOD INNER PANEL	STEEL	20.3	FRP	15.8
HOOD HINGE BRACKET	STEEL	10.0	HSS	8.0
RADIATOR SUPPORT	STEEL	40.0	HSS	32.0
GRILLE LOWER PANEL	STEEL	4.0	FRP	3.1
FENDER OUTER PANEL	STEEL	35.1	FRP	27.4
FENDER INNER PANEL	STEEL	16.9	FRP	13.2
FRONT WHEEL HOUSE	STEEL	21.0	FRP	16.4
CAB ROOF	STEEL	52.0	FRP	40.6
CAB REAR PANEL	STEEL	31.5	FRP	24.6
DASH PANEL	STEEL	32.0	FRP	25.0
CAB FLOOR	STEEL	44.0	FRP	34.3
COWL SIDE	STEEL	22.0	FRP	17.2
COWL VENT PANEL	STEEL	4.0	FRP	3.1
DOOR OUTER PANEL	STEEL	40.0	FRP	31.2
DOOR INNER PANEL	STEEL	40.0	FRP	31.2
DOOR REGULATOR	STEEL	8.0	HSS	6.4
SILL	STEEL	17.0	HSS	13.6
SEAT FRAME	STEEL	44.0	HSS	35.2
BOX FLOOR	STEEL	107.8	FRP	84.1
FLOOR SUPPORT CHANNEL	STEEL	55.0	HSS	44.0
BOX FRONT PANEL	STEEL	22.0	FRP	17.2
TAILGATE	STEEL	44.0	FRP	34.3
SIDE PANEL OUTER	STEEL	42.8	FRP	33.4
SIDE PANEL INNER	STEEL	60.0	FRP	46.8
REAR WHEEL HOUSE	STEEL	24.0	FRP	18.7
FRAME	STEEL	350.0	HSS	280.0
ENGINE SUPPORT CROSSMEMBER	STEEL	20.5	HSS	16.4

TABLE B-2 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
FRONT BUMPER	STEEL	29.0	FOAM	14.5
BUMPER MOUNTING BRACKET	STEEL	4.0	HSS	3.2
BATTERY TRAY	STEEL	3.0	FRP	2.3
RADIATOR CORE	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
ENGINE MOUNTING BRACKET	STEEL	8.5	HSS	6.8
FRONT SPRING	STEEL	24.0	HRP	9.6
LOWER CONTROL ARM	STEEL	18.0	HSS	14.4
UPPER CONTROL ARM	STEEL	14.5	HSS	11.6
REAR SPRING	STEEL	69.0	HRP	27.6
REAR SPRING SHACKLE	STEEL	3.0	HSS	2.4
REAR AXLE U-BOLT PLATE	STEEL	10.0	HSS	8.0
STEERING GEAR HOUSING	IRON	15.5	ALUM	7.8
MASTER CYLINDER	IRON	10.2	ALUM	5.1
BRAKE AND CLUTCH PEDALS	STEEL	6.0	HSS	4.8
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HSS	3.2
DRIVE SHAFT	STEEL	24.0	HRP	9.6
BRAKE DISC	IRON	55.5	ALUM	27.8
BRAKE DRUM	IRON	26.0	ALUM	13.0
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	IRON	145.0
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	FRP	4.7
VALVE COVER	STEEL	6.5	FRP	5.1
OIL PAN	STEEL	7.5	FRP	5.9
WATER PUMP	IRON	7.5	ALUM	3.7

TABLE B-2 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
CONNECTING ROD	STEEL	10.0	STEEL	10.0
WHEEL	STEEL	107.5	HRP	43.0
FUEL TANK	TERNE	21.0	HDPE	13.6
WINDSHIELD	GLASS	31.0	GLASS	24.8
DOOR WINDOW	GLASS	16.0	GLASS	10.7
REAR WINDOW	GLASS	13.5	GLASS	9.0

TABLE B-3 1978 DODGE D 100 PICKUP TRUCK EQUIPPED WITH 225 CID ENGINE, ALUMINUM DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
HOOD OUTER PANEL	STEEL	34.7	ALUM	20.1
HOOD INNER PANEL	STEEL	20.3	ALUM	11.8
HOOD HINGE BRACKET	STEEL	10.0	HSS	8.0
RADIATOR SUPPORT	STEEL	40.0	HSS	32.0
GRILLE LOWER PANEL	STEEL	4.0	ALUM	2.3
FENDER OUTER PANEL	STEEL	35.1	ALUM	20.4
FENDER INNER PANEL	STEEL	16.9	ALUM	9.8
FRONT WHEEL HOUSE	STEEL	21.0	ALUM	12.2
CAB ROOF	STEEL	52.0	ALUM	30.2
CAB REAR PANEL	STEEL	31.5	ALUM	18.3
DASH PANEL	STEEL	32.0	ALUM	18.6
CAB FLOOR	STEEL	44.0	ALUM	25.5
COWL SIDE	STEEL	22.0	ALUM	12.8
COWL VENT PANEL	STEEL	4.0	ALUM	2.3
DOOR OUTER PANEL	STEEL	40.0	ALUM	23.2
DOOR INNER PANEL	STEEL	40.0	ALUM	23.2
DOOR REGULATOR	STEEL	8.0	HSS	6.4
SILL	STEEL	17.0	HSS	13.6
SEAT FRAME	STEEL	44.0	HSS	35.2
BOX FLOOR	STEEL	107.8	ALUM	62.5
FLOOR SUPPORT CHANNEL	STEEL	55.0	HSS	44.0
BOX FRONT PANEL	STEEL	22.0	ALUM	12.8
TAILGATE	STEEL	44.0	ALUM	25.5
SIDE PANEL OUTER	STEEL	42.8	ALUM	24.8
SIDE PANEL INNER	STEEL	60.0	ALUM	34.8
REAR WHEEL HOUSE	STEEL	24.0	ALUM	13.9
FRAME	STEEL	350.0	HSS	288.0
ENGINE SUPPORT CROSSMEMBER	STEEL	20.5	HSS	16.4

TABLE B-3 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
FRONT BUMPER	STEEL	29.0	FOAM	14.5
BUMPER MOUNTING BRACKET	STEEL	4.0	HSS	3.2
BATTERY TRAY	STEEL	3.0	ALUM	1.7
RADIATOR CORE	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
ENGINE MOUNTING BRACKET	STEEL	8.5	HSS	6.8
FRONT SPRING	STEEL	24.0	HRP	9.6
LOWER CONTROL ARM	STEEL	18.0	HSS	14.4
UPPER CONTROL ARM	STEEL	14.5	HSS	11.6
REAR SPRING	STEEL	69.0	HRP	27.6
REAR SPRING SHACKLE	STEEL	3.0	HSS	2.4
REAR AXLE U-BOLT PLATE	STEEL	10.0	HSS	8.0
STEERING GEAR HOUSING	IRON	15.5	ALUM	7.8
MASTER CYLINDER	IRON	10.2	ALUM	5.1
BRAKE AND CLUTCH PEDALS	STEEL	6.0	HSS	4.8
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HSS	3.2
DRIVE SHAFT	STEEL	24.0	HRP	9.6
BRAKE DISC	IRON	55.5	ALUM	27.8
BRAKE DRUM	IRON	26.0	ALUM	13.0
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	ALUM	72.5
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	ALUM	3.5
VALVE COVER	STEEL	6.5	ALUM	3.8
OIL PAN	STEEL	7.5	ALUM	4.4
WATER PUMP	IRON	7.5	ALUM	3.7

TABLE B-3 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
CONNECTING ROD	STEEL	10.0	STEEL	10.0
WHEEL	STEEL	107.5	ALUM	53.8
FUEL TANK	TERNE	21.0	HDPE	13.6
WINDSHIELD	GLASS	31.0	GLASS	24.8
DOOR WINDOW	GLASS	16.0	GLASS	10.7
REAR WINDOW	GLASS	13.5	GLASS	9.0

TABLE B-4 1978 DODGE D 100 PICKUP TRUCK EQUIPPED WITH 225 CID ENGINE HRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
HOOD OUTER PANEL	STEEL	34.7	HRP	17.4
HOOD INNER PANEL	STEEL	20.3	HRP	10.2
HOOD HINGE BRACKET	STEEL	10.0	HRP	4.0
RADIATOR SUPPORT	STEEL	40.0	HRP	16.0
GRILLE LOWER PANEL	STEEL	4.0	HRP	2.0
FENDER OUTER PANEL	STEEL	35.1	HRP	17.6
FENDER INNER PANEL	STEEL	16.9	HRP	8.5
FRONT WHEEL HOUSE	STEEL	21.0	HRP	10.5
CAB ROOF	STEEL	52.0	HRP	26.0
CAB REAR PANEL	STEEL	31.5	HRP	15.8
DASH PANEL	STEEL	32.0	HRP	16.0
CAB FLOOR	STEEL	44.0	HRP	22.0
COWL SIDE	STEEL	22.0	HRP	11.0
COWL VENT PANEL	STEEL	4.0	HRP	2.0
DOOR OUTER PANEL	STEEL	40.0	HRP	20.0
DOOR INNER PANEL	STEEL	40.0	HRP	20.0
DOOR REGULATOR	STEEL	8.0	HRP	3.2
SILL	STEEL	17.0	HRP	6.8
SEAT FRAME	STEEL	44.0	HRP	17.6
BOX FLOOR	STEEL	107.8	HRP	53.9
FLOOR SUPPORT CHANNEL	STEEL	55.0	HRP	22.0
BOX FRONT PANEL	STEEL	22.0	HRP	11.0
TAILGATE	STEEL	44.0	HRP	22.0
SIDE PANEL OUTER	STEEL	42.8	HRP	21.4
SIDE PANEL INNER	STEEL	60.0	HRP	30.0
REAR WHEEL HOUSE	STEEL	24.0	HRP	12.0
FRAME	STEEL	350.0	HRP	140.0
ENGINE SUPPORT CROSSMEMBER	STEEL	20.5	HRP	8.2

TABLE B-4 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
FRONT BUMPER	STEEL	29.0	FOAM	14.5
BUMPER MOUNTING BRACKET	STEEL	4.0	HRP	1.6
BATTERY TRAY	STEEL	3.0	HRP	1.5
RADIATOR CORE	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
ENGINE MOUNTING BRACKET	STEEL	8.5	HRP	3.4
FRONT SPRING	STEEL	24.0	HRP	9.6
LOWER CONTROL ARM	STEEL	18.0	HRP	7.2
UPPER CONTROL ARM	STEEL	14.5	HRP	5.8
REAR SPRING	STEEL	69.0	HRP	27.6
REAR SPRING SHACKLE	STEEL	3.0	HRP	1.2
REAR AXLE U-BOLT PLATE	STEEL	10.0	HRP	4.0
STEERING GEAR HOUSING	IRON	15.5	ALUM	7.8
MASTER CYLINDER	IRON	10.2	ALUM	5.1
BRAKE AND CLUTCH PEDALS	STEEL	6.0	HRP	2.4
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HRP	1.6
DRIVE SHAFT	STEEL	24.0	HRP	9.6
BRAKE DISC	IRON	55.5	ALUM	27.8
BRAKE DRUM	IRON	26.0	ALUM	13.0
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	ALUM	72.5
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	HRP	3.0
VALVE COVER	STEEL	6.5	HRP	3.3
OIL PAN	STEEL	7.5	HRP	3.8
WATER PUMP	IRON	7.5	ALUM	3.8

TABLE B-4 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
CONNECTING ROD	STEEL	10.0	HRP	4.0
WHEEL	STEEL	107.5	HRP	43.0
FUEL TANK	TERNE	21.0	HDPE	13.6
WINDSHIELD	GLASS	31.0	GLASS	24.8
DOOR WINDOW	GLASS	16.0	GLASS	10.7
REAR WINDOW	GLASS	13.5	GLASS	9.0

TABLE B-5 1978 DODGE B 100 VAN EQUIPPED WITH 225 CID ENGINE, HSS DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
ROOF	STEEL	125.0	HSS	103.8
DASH PANEL	STEEL	33.0	HSS	27.4
FLOOR	STEEL	155.0	HSS	128.7
SIDE PANEL LEFT	STEEL	70.0	HSS	58.1
SIDE PANEL RIGHT	STEEL	35.0	HSS	29.1
FRONT QUARTER OUTER	STEEL	15.0	HSS	12.5
FRONT QUARTER INNER	STEEL	7.0	HSS	5.8
UNDERBODY STRUCTURE	STEEL	250.0	HSS	200.0
FRONT DOOR OUTER	STEEL	39.0	HSS	32.4
FRONT DOOR INNER	STEEL	39.0	HSS	32.4
SIDE DOOR OUTER	STEEL	28.5	HSS	23.7
SIDE DOOR INNER	STEEL	28.5	HSS	23.7
REAR DOOR OUTER	STEEL	25.0	HSS	20.8
REAR DOOR INNER	STEEL	25.0	HSS	20.8
COWL VENT PANEL	STEEL	4.0	HSS	3.3
DOOR WINDOW REGULATOR	STEEL	8.0	HSS	6.4
HOOD	STEEL	17.5	HSS	14.5
FRONT STRUCTURE	STEEL	7.5	HSS	6.0
SIDE SILL	STEEL	28.0	HSS	22.4
REAR SILL	STEEL	14.0	HSS	11.2
ROOF BOW	STEEL	26.0	HSS	20.8
SIDE CHANNEL	STEEL	18.0	HSS	14.4
UNDERBODY RAIL	STEEL	112.0	HSS	89.6
WHEELHOUSE	STEEL	48.0	HSS	39.8
FRONT SUSPENSION CROSS-MEMBER	STEEL	36.0	HSS	28.8
ENGINE SUPPORT CROSSMEMBER	STEEL	5.5	HSS	4.4
SEAT PLATFORM	STEEL	15.3	HSS	12.2

TABLE B-5 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
SEAT FRAME	STEEL	4.5	HSS	3.6
FRONT BUMPER	STEEL	28.8	FOAM	14.4
REAR BUMPER	STEEL	22.8	FOAM	11.4
BUMPER MOUNTING & BRACKET	STEEL	11.5	HSS	9.2
RADIATOR SUPPORT BRACKET	STEEL	7.5	HSS	6.0
FRONT SPRING	STEEL	23.0	HRP	9.2
UPPER CONTROL ARM	STEEL	18.0	HSS	14.4
LOWER CONTROL ARM	STEEL	14.5	HSS	11.6
REAR SPRING	STEEL	57.6	HRP	23.0
REAR SPRING SHACKLE	STEEL	9.0	HSS	7.2
AXLE U-BOLT PLATE	STEEL	5.0	HSS	4.0
DRIVE SHAFT	STEEL	12.5	HRP	5.0
MASTER CYLINDER	IRON	10.2	ALUM	5.1
FRONT BRAKE DISC	IRON	36.5	ALUM	18.2
REAR BRAKE DRUM	IRON	22.0	ALUM	11.0
BRAKE PEDAL	STEEL	6.0	HSS	4.8
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HSS	3.2
WHEEL	STEEL	107.5	ALUM	53.8
FUEL TANK	TERNE	22.2	HDPE	14.4
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	IRON	145.0
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	HSS	5.0
VALVE COVER	STEEL	6.5	HSS	5.4
OIL PAN	STEEL	7.5	HSS	6.2
WATER PUMP	STEEL	7.5	ALUM	3.8
CONNECTING ROD	STEEL	10.0	STEEL	10.0

TABLE B-5 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
WINDSHIELD	GLASS	43.5	GLASS	34.8
DOOR WINDOW	GLASS	14.0	GLASS	9.3
RADIATOR	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
STEERING GEAR HOUSING	IRON	13.5	ALUM	6.8

TABLE B-6 1978 DODGE B 100 VAN EQUIPPED WITH 225 CID ENGINE, FRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
ROOF	STEEL	125.0	FRP	97.5
DASH PANEL	STEEL	33.0	FRP	25.7
FLOOR	STEEL	155.0	FRP	120.9
SIDE PANEL LEFT	STEEL	70.0	FRP	54.6
SIDE PANEL RIGHT	STEEL	35.0	FRP	27.3
FRONT QUARTER OUTER	STEEL	15.0	FRP	11.7
FRONT QUARTER INNER	STEEL	7.0	FRP	5.5
UNDERBODY STRUCTURE	STEEL	250.0	HSS	200.0
FRONT DOOR OUTER	STEEL	39.0	FRP	30.4
FRONT DOOR INNER	STEEL	39.0	FRP	30.4
SIDE DOOR OUTER	STEEL	28.5	FRP	22.2
SIDE DOOR INNER	STEEL	28.5	FRP	22.2
REAR DOOR OUTER	STEEL	25.0	FRP	19.5
REAR DOOR INNER	STEEL	25.0	FRP	19.5
COWL VENT PANEL	STEEL	4.0	FRP	3.1
DOOR WINDOW REGULATOR	STEEL	8.0	HSS	6.4
HOOD	STEEL	17.5	FRP	13.7
FRONT STRUCTURE	STEEL	7.5	HSS	6.0
SIDE SILL	STEEL	28.0	HSS	22.4
REAR SILL	STEEL	14.0	HSS	11.2
ROOF BOW	STEEL	26.0	HSS	20.8
SIDE CHANNEL	STEEL	18.0	HSS	14.4
UNDERBODY RAIL	STEEL	112.0	HSS	89.6
WHEELHOUSE	STEEL	48.0	FRP	37.4
FRONT SUSPENSION CROSS-MEMBER	STEEL	36.0	HSS	28.8
ENGINE SUPPORT CROSSMEMBER	STEEL	5.5	HSS	4.4
SEAT PLATFORM	STEEL	15.3	HSS	12.2

TABLE B-6 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
SEAT FRAME	STEEL	4.5	HSS	3.6
FRONT BUMPER	STEEL	28.8	FOAM	14.4
REAR BUMPER	STEEL	22.8	FOAM	11.4
BUMPER MOUNTING & BRACKET	STEEL	11.5	HSS	9.2
RADIATOR SUPPORT BRACKET	STEEL	7.5	HSS	6.0
FRONT SPRING	STEEL	23.0	HRP	9.2
UPPER CONTROL ARM	STEEL	18.0	HSS	14.4
LOWER CONTROL ARM	STEEL	14.5	HSS	11.6
REAR SPRING	STEEL	57.6	HRP	23.0
REAR SPRING SHACKLE	STEEL	9.0	HSS	7.2
AXLE U-BOLT PLATE	STEEL	5.0	HSS	4.0
DRIVE SHAFT	STEEL	12.5	HRP	5.0
MASTER CYLINDER	IRON	10.2	ALUM	5.1
FRONT BRAKE DISC	IRON	36.5	ALUM	18.2
REAR BRAKE DRUM	IRON	22.0	ALUM	11.0
BRAKE PEDAL	STEEL	6.0	HSS	4.8
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HSS	3.2
WHEEL	STEEL	107.5	HRP	43.0
FUEL TANK	TERNE	22.2	HDPE	14.4
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	IRON	145.0
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	FRP	4.7
VALVE COVER	STEEL	6.5	FRP	5.1
OIL PAN	STEEL	7.5	FRP	5.9
WATER PUMP	STEEL	7.5	ALUM	3.8
CONNECTING ROD	STEEL	10.0	STEEL	10.0

TABLE B-6 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
WINDSHIELD	GLASS	43.5	GLASS	34.8
DOOR WINDOW	GLASS	14.0	GLASS	9.3
RADIATOR	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
STEERING GEAR HOUSING	IRON	13.5	ALUM	6.8

TABLE B-7 1978 DODGE B 100 VAN EQUIPPED WITH 225 CID ENGINE, ALUMINUM DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
ROOF	STEEL	125.0	ALUM	72.5
DASH PANEL	STEEL	33.0	ALUM	19.1
FLOOR	STEEL	155.0	ALUM	89.9
SIDE PANEL LEFT	STEEL	70.0	ALUM	40.6
SIDE PANEL RIGHT	STEEL	35.0	ALUM	20.3
FRONT QUARTER OUTER	STEEL	15.0	ALUM	8.7
FRONT QUARTER INNER	STEEL	7.0	ALUM	4.1
UNDERBODY STRUCTURE	STEEL	250.0	HSS	200.0
FRONT DOOR OUTER	STEEL	39.0	ALUM	22.6
FRONT DOOR INNER	STEEL	39.0	ALUM	22.6
SIDE DOOR OUTER	STEEL	28.5	ALUM	16.5
SIDE DOOR INNER	STEEL	28.5	ALUM	16.5
REAR DOOR OUTER	STEEL	25.0	ALUM	14.5
REAR DOOR INNER	STEEL	25.0	ALUM	14.5
COWL VENT PANEL	STEEL	4.0	ALUM	2.3
DOOR WINDOW REGULATOR	STEEL	8.0	HSS	6.4
HOOD	STEEL	17.5	ALUM	10.2
FRONT STRUCTURE	STEEL	7.5	HSS	6.0
SIDE SILL	STEEL	28.0	HSS	22.4
REAR SILL	STEEL	14.0	HSS	11.2
ROOF BOW	STEEL	26.0	HSS	20.8
SIDE CHANNEL	STEEL	18.0	HSS	14.4
UNDERBODY RAIL	STEEL	112.0	HSS	89.6
WHEELHOUSE	STEEL	48.0	ALUM	27.8
FRONT SUSPENSION CROSS-MEMBER	STEEL	36.0	HSS	28.8
ENGINE SUPPORT CROSSMEMBER	STEEL	5.5	HSS	4.4
SEAT PLATFORM	STEEL	15.3	HSS	12.2

TABLE B-7 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
SEAT FRAME	STEEL	4.5	HSS	3.6
FRONT BUMPER	STEEL	28.8	FOAM	14.4
REAR BUMPER	STEEL	22.8	FOAM	11.4
BUMPER MOUNTING & BRACKET	STEEL	11.5	HSS	9.2
RADIATOR SUPPORT BRACKET	STEEL	7.5	HSS	6.0
FRONT SPRING	STEEL	23.0	HRP	9.2
UPPER CONTROL ARM	STEEL	18.0	HSS	14.4
LOWER CONTROL ARM	STEEL	14.5	HSS	11.6
REAR SPRING	STEEL	57.6	HRP	23.0
REAR SPRING SHACKLE	STEEL	9.0	HSS	7.2
AXLE U-BOLT PLATE	STEEL	5.0	HSS	4.0
DRIVE SHAFT	STEEL	12.5	HRP	5.0
MASTER CYLINDER	IRON	10.2	ALUM	5.1
FRONT BRAKE DISC	IRON	36.5	ALUM	18.2
REAR BRAKE DRUM	IRON	22.0	ALUM	11.0
BRAKE PEDAL	STEEL	6.0	HSS	4.8
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HSS	3.2
WHEEL	STEEL	107.5	ALUM	53.8
FUEL TANK	TERNE	22.2	HDPE	14.4
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	ALUM	70.5
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	ALUM	3.5
VALVE COVER	STEEL	6.5	ALUM	3.8
OIL PAN	STEEL	7.5	ALUM	4.4
WATER PUMP	STEEL	7.5	ALUM	3.8
CONNECTING ROD	STEEL	10.0	STEEL	10.0

TABLE B-7 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
WINDSHIELD	GLASS	43.5	GLASS	34.8
DOOR WINDOW	GLASS	14.0	GLASS	9.3
RADIATOR	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
STEERING GEAR HOUSING	IRON	13.5	ALUM	6.8

TABLE B-8 1978 DODGE B 100 VAN EQUIPPED WITH 225 CID ENGINE, HRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
ROOF	STEEL	125.0	HRP	62.5
DASH PANEL	STEEL	33.0	HRP	16.5
FLOOR	STEEL	155.0	HRP	77.5
SIDE PANEL LEFT	STEEL	70.0	HRP	35.0
SIDE PANEL RIGHT	STEEL	35.0	HRP	17.5
FRONT QUARTER OUTER	STEEL	15.0	HRP	7.5
FRONT QUARTER INNER	STEEL	7.0	HRP	3.5
UNDERBODY STRUCTURE	STEEL	250.0	HRP	100.0
FRONT DOOR OUTER	STEEL	39.0	HRP	19.5
FRONT DOOR INNER	STEEL	39.0	HRP	19.5
SIDE DOOR OUTER	STEEL	28.5	HRP	14.3
SIDE DOOR INNER	STEEL	28.5	HRP	14.3
REAR DOOR OUTER	STEEL	25.0	HRP	12.5
REAR DOOR INNER	STEEL	25.0	HRP	12.5
COWL VENT PANEL	STEEL	4.0	HRP	2.0
DOOR WINDOW REGULATOR	STEEL	8.0	HRP	3.2
HOOD	STEEL	17.5	HRP	8.8
FRONT STRUCTURE	STEEL	7.5	HRP	3.0
SIDE SILL	STEEL	28.0	HRP	11.3
REAR SILL	STEEL	14.0	HRP	5.6
ROOF BOW	STEEL	26.0	HRP	10.4
SIDE CHANNEL	STEEL	18.0	HRP	7.2
UNDERBODY RAIL	STEEL	112.0	HRP	44.8
WHEELHOUSE	STEEL	48.0	HRP	24.0
FRONT SUSPENSION CROSS-MEMBER	STEEL	36.0	HRP	14.4
ENGINE SUPPORT CROSSMEMBER	STEEL	5.5	HRP	2.2
SEAT PLATFORM	STEEL	15.3	HRP	6.6

TABLE B-8 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
SEAT FRAME	STEEL	4.5	HRP	1.8
FRONT BUMPER	STEEL	28.8	FOAM	14.4
REAR BUMPER	STEEL	22.8	FOAM	11.4
BUMPER MOUNTING & BRACKET	STEEL	11.5	HRP	4.6
RADIATOR SUPPORT BRACKET	STEEL	7.5	HRP	3.0
FRONT SPRING	STEEL	23.0	HRP	9.2
UPPER CONTROL ARM	STEEL	18.0	HRP	7.2
LOWER CONTROL ARM	STEEL	14.5	HRP	5.8
REAR SPRING	STEEL	57.6	HRP	23.0
REAR SPRING SHACKLE	STEEL	9.0	HRP	3.6
AXLE U-BOLT PLATE	STEEL	5.0	HRP	2.0
DRIVE SHAFT	STEEL	12.5	HRP	5.0
MASTER CYLINDER	IRON	10.2	ALUM	5.1
FRONT BRAKE DISC	IRON	36.5	ALUM	18.2
REAR BRAKE DRUM	IRON	22.0	ALUM	11.0
BRAKE PEDAL	STEEL	6.0	HRP	2.4
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HRP	1.6
WHEEL	STEEL	107.5	HRP	43.0
FUEL TANK	TERNE	22.2	HDPE	14.4
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	ALUM	70.5
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	HRP	3.0
VALVE COVER	STEEL	6.5	HRP	3.3
OIL PAN	STEEL	7.5	HRP	3.8
WATER PUMP	STEEL	7.5	ALUM	3.8
CONNECTING ROD	STEEL	10.0	HRP	4.0

TABLE B-8 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
WINDSHIELD	GLASS	43.5	GLASS	34.8
DOOR WINDOW	GLASS	14.0	GLASS	9.3
RADIATOR	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
STEERING GEAR HOUSING	IRON	13.5	ALUM	6.8

TABLE B-9 1978 DODGE RAMCHARGER EQUIPPED WITH 225 CID ENGINE, HSS DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
TOP	STEEL	175.0	HSS	145.3
DASH	STEEL	32.0	HSS	26.6
FLOOR	STEEL	97.0	HSS	80.5
TAILGATE	STEEL	44.0	HSS	36.5
HOOD OUTER PANEL	STEEL	34.7	HSS	28.8
HOOD INNER PANEL	STEEL	20.3	HSS	16.8
HOOD HINGE BRACKET	STEEL	10.0	HSS	8.0
FRONT FENDER OUTER	STEEL	35.1	HSS	29.1
FRONT FENDER INNER	STEEL	16.9	HSS	14.0
FRONT WHEELHOUSE	STEEL	21.0	HSS	17.4
RADIATOR SUPPORT	STEEL	40.0	HSS	32.0
GRILLE LOWER PANEL	STEEL	4.0	HSS	3.3
COWL SIDE	STEEL	22.0	HSS	18.3
COWL VENT PANEL	STEEL	4.0	HSS	3.3
DOOR OUTER PANEL	STEEL	40.0	HSS	33.2
DOOR INNER PANEL	STEEL	40.0	HSS	33.2
SIDE PANEL OUTER	STEEL	46.8	HSS	38.8
SIDE PANEL INNER	STEEL	32.7	HSS	27.1
REAR WHEELHOUSE	STEEL	24.0	HSS	19.9
FRAME	STEEL	300.0	HSS	240.0
ENGINE SUPPORT CROSSMEMBER	STEEL	20.5	HSS	16.4
ENGINE MOUNTING BRACKET	STEEL	8.5	HSS	6.8
SEAT FRAME	STEEL	12.0	HSS	9.6
FRONT BUMPER	STEEL	29.0	FOAM	14.5
REAR BUMPER	STEEL	23.0	FOAM	11.5
BUMPER MOUNTING BRACKET	STEEL	9.0	HSS	7.2
FRONT SPRING	STEEL	75.0	HRP	30.0
REAR SPRING	STEEL	80.0	HRP	32.0

TABLE B-9 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
REAR SPRING SHACKLE	STEEL	3.0	HSS	2.4
AXLE U-BOLT PLATE	STEEL	10.0	HSS	8.0
STEERING GEAR HOUSING	IRON	15.5	ALUM	7.8
MASTER CYLINDER	IRON	10.2	ALUM	5.1
BRAKE & CLUTCH PEDAL	STEEL	6.0	HSS	4.8
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HSS	3.2
DRIVE SHAFT	STEEL	24.0	HRP	9.6
WHEEL	STEEL	107.5	ALUM	53.8
FUEL TANK	TERNE	24.0	HDPE	15.5
RADIATOR	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
WINDSHIELD	GLASS	31.0	GLASS	24.8
REAR WINDOW	GLASS	18.0	GLASS	12.0
DOOR GLASS	GLASS	16.0	GLASS	10.7
SIDE WINDOW	GLASS	35.0	GLASS	23.3
BRAKE DISC	IRON	55.5	ALUM	27.8
BRAKE DRUM	IRON	26.0	ALUM	13.0
BATTERY TRAY	STEEL	3.0	HSS	2.5
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	IRON	145.0
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	HSS	5.0
VALVE COVER	STEEL	6.5	HSS	5.4
OIL PAN	STEEL	7.5	HSS	6.2
WATER PUMP	IRON	7.5	ALUM	3.7
CONNECTING ROD	STEEL	10.0	STEEL	10.0

TABLE B-10 DODGE RAMCHARGER EQUIPPED WITH 225 CID ENGINE, FRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
TOP	STEEL	175.0	FRP	136.5
DASH	STEEL	32.0	FRP	25.0
FLOOR	STEEL	97.0	FRP	75.7
TAILGATE	STEEL	44.0	FRP	34.3
HOOD OUTER PANEL	STEEL	34.7	FRP	27.1
HOOD INNER PANEL	STEEL	20.3	FRP	15.8
HOOD HINGE BRACKET	STEEL	10.0	HSS	8.0
FRONT FENDER OUTER	STEEL	35.1	FRP	27.4
FRONT FENDER INNER	STEEL	16.9	FRP	13.2
FRONT WHEELHOUSE	STEEL	21.0	FRP	16.4
RADIATOR SUPPORT	STEEL	40.0	HSS	32.0
GRILLE LOWER PANEL	STEEL	4.0	FRP	3.1
COWL SIDE	STEEL	22.0	FRP	17.2
COWL VENT PANEL	STEEL	4.0	FRP	3.1
DOOR OUTER PANEL	STEEL	40.0	FRP	31.2
DOOR INNER PANEL	STEEL	40.0	FRP	31.2
SIDE PANEL OUTER	STEEL	46.8	FRP	36.5
SIDE PANEL INNER	STEEL	32.7	FRP	25.5
REAR WHEELHOUSE	STEEL	24.0	FRP	18.7
FRAME	STEEL	300.0	FRP	234.0
ENGINE SUPPORT CROSSMEMBER	STEEL	20.5	HSS	16.4
ENGINE MOUNTING BRACKET	STEEL	8.5	HSS	6.8
SEAT FRAME	STEEL	12.0	HSS	9.6
FRONT BUMPER	STEEL	29.0	FOAM	14.5
REAR BUMPER	STEEL	23.0	FOAM	11.5
BUMPER MOUNTING BRACKET	STEEL	9.0	HSS	7.2
FRONT SPRING	STEEL	75.0	HRP	30.0
REAR SPRING	STEEL	80.0	HRP	32.0

TABLE B-10 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
REAR SPRING SHACKLE	STEEL	3.0	HSS	2.4
AXLE U-BOLT PLATE	STEEL	10.0	HSS	8.0
STEERING GEAR HOUSING	IRON	15.5	ALUM	7.8
MASTER CYLINDER	IRON	10.2	ALUM	5.1
BRAKE & CLUTCH PEDAL	STEEL	6.0	HSS	4.8
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HSS	3.2
DRIVE SHAFT	STEEL	24.0	HRP	9.6
WHEEL	STEEL	107.5	ALUM	53.8
FUEL TANK	TERNE	24.0	HDPE	15.5
RADIATOR	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
WINDSHIELD	GLASS	31.0	GLASS	24.8
REAR WINDOW	GLASS	18.0	GLASS	12.0
DOOR GLASS	GLASS	16.0	GLASS	10.7
SIDE WINDOW	GLASS	35.0	GLASS	23.3
BRAKE DISC	IRON	55.5	ALUM	27.8
BRAKE DRUM	IRON	26.0	ALUM	13.0
BATTERY TRAY	STEEL	3.0	ALUM	2.5
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	IRON	145.0
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	FRP	4.7
VALVE COVER	STEEL	6.5	FRP	5.1
OIL PAN	STEEL	7.5	FRP	5.9
WATER PUMP	IRON	7.5	ALUM	3.7
CONNECTING ROD	STEEL	10.0	STEEL	10.0

TABLE B-11 1978 DODGE RAMCHARGER EQUIPPED WITH 225 CID ENGINE, ALUMINUM DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT.(LBS)	MATERIAL	WT.(LBS)
TOP	STEEL	175.0	ALUM	101.5
DASH	STEEL	32.0	ALUM	18.6
FLOOR	STEEL	97.0	ALUM	56.3
TAILGATE	STEEL	44.0	ALUM	25.5
HOOD OUTER PANEL	STEEL	34.7	ALUM	20.1
HOOD INNER PANEL	STEEL	20.3	ALUM	11.8
HOOD HINGE BRACKET	STEEL	10.0	HSS	8.0
FRONT FENDER OUTER	STEEL	35.1	ALUM	20.4
FRONT FENDER INNER	STEEL	16.9	ALUM	9.8
FRONT WHEELHOUSE	STEEL	21.0	ALUM	12.2
RADIATOR SUPPORT	STEEL	40.0	HSS	32.0
GRILLE LOWER PANEL	STEEL	4.0	ALUM	2.3
COWL SIDE	STEEL	22.0	ALUM	12.8
COWL VENT PANEL	STEEL	4.0	ALUM	2.3
DOOR OUTER PANEL	STEEL	40.0	ALUM	23.2
DOOR INNER PANEL	STEEL	40.0	ALUM	23.2
SIDE PANEL OUTER	STEEL	46.8	ALUM	27.1
SIDE PANEL INNER	STEEL	32.7	ALUM	19.0
REAR WHEELHOUSE	STEEL	24.0	ALUM	13.9
FRAME	STEEL	300.0	ALUM	174.0
ENGINE SUPPORT CROSSMEMBER	STEEL	20.5	HSS	16.4
ENGINE MOUNTING BRACKET	STEEL	8.5	HSS	6.8
SEAT FRAME	STEEL	12.0	HSS	9.6
FRONT BUMPER	STEEL	29.0	FOAM	14.5
REAR BUMPER	STEEL	23.0	FOAM	11.5
BUMPER MOUNTING BRACKET	STEEL	9.0	HSS	7.2
FRONT SPRING	STEEL	75.0	HRP	30.0
REAR SPRING	STEEL	80.0	HRP	32.0

TABLE B-11 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
REAR SPRING SHACKLE	STEEL	3.0	HSS	2.4
AXLE U-BOLT PLATE	STEEL	10.0	HSS	8.0
STEERING GEAR HOUSING	IRON	15.5	ALUM	7.8
MASTER CYLINDER	IRON	10.2	ALUM	5.1
BRAKE & CLUTCH PEDAL	STEEL	6.0	HSS	4.8
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HSS	3.2
DRIVE SHAFT	STEEL	24.0	HRP	9.6
WHEEL	STEEL	107.5	ALUM	53.8
FUEL TANK	TERNE	24.0	HDPE	15.5
RADIATOR	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
WINDSHIELD	GLASS	31.0	GLASS	24.8
REAR WINDOW	GLASS	18.0	GLASS	12.0
DOOR GLASS	GLASS	16.0	GLASS	10.7
SIDE WINDOW	GLASS	35.0	GLASS	23.3
BRAKE DISC	IRON	55.5	ALUM	27.8
BRAKE DRUM	IRON	26.0	ALUM	13.0
BATTERY TRAY	STEEL	3.0	ALUM	2.5
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	ALUM	72.5
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	ALUM	3.5
VALVE COVER	STEEL	6.5	ALUM	3.8
OIL PAN	STEEL	7.5	ALUM	4.4
WATER PUMP	IRON	7.5	ALUM	3.7
CONNECTING ROD	STEEL	10.0	STEEL	10.0

TABLE B-12 1978 DODGE RAMCHARGER EQUIPPED WITH 225 CID ENGINE, HRP DOMINANT CASE

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
TOP	STEEL	175.0	HRP	87.5
DASH	STEEL	32.0	HRP	16.0
FLOOR	STEEL	97.0	HRP	48.5
TAILGATE	STEEL	44.0	HRP	22.0
HOOD OUTER PANEL	STEEL	34.7	HRP	17.4
HOOD INNER PANEL	STEEL	20.3	HRP	10.2
HOOD HINGE BRACKET	STEEL	10.0	HRP	4.0
FRONT FENDER OUTER	STEEL	35.1	HRP	17.6
FRONT FENDER INNER	STEEL	16.9	HRP	8.5
FRONT WHEELHOUSE	STEEL	21.0	HRP	10.5
RADIATOR SUPPORT	STEEL	40.0	HRP	16.0
GRILLE LOWER PANEL	STEEL	4.0	HRP	2.0
COWL SIDE	STEEL	22.0	HRP	11.0
COWL VENT PANEL	STEEL	4.0	HRP	2.0
DOOR OUTER PANEL	STEEL	40.0	HRP	20.0
DOOR INNER PANEL	STEEL	40.0	HRP	20.0
SIDE PANEL OUTER	STEEL	46.8	HRP	23.4
SIDE PANEL INNER	STEEL	32.7	HRP	16.4
REAR WHEELHOUSE	STEEL	24.0	HRP	12.0
FRAME	STEEL	300.0	HRP	120.0
ENGINE SUPPORT CROSSMEMBER	STEEL	20.5	HRP	8.2
ENGINE MOUNTING BRACKET	STEEL	8.5	HRP	3.4
SEAT FRAME	STEEL	12.0	HRP	4.8
FRONT BUMPER	STEEL	29.0	FOAM	14.5
REAR BUMPER	STEEL	23.0	FOAM	11.5
BUMPER MOUNTING BRACKET	STEEL	9.0	HRP	3.6
FRONT SPRING	STEEL	75.0	HRP	30.0
REAR SPRING	STEEL	80.0	HRP	32.0

TABLE B-12 (CONT'D)

PART NAME	CURRENT		ALTERNATIVE	
	MATERIAL	WT. (LBS)	MATERIAL	WT. (LBS)
REAR SPRING SHACKLE	STEEL	3.0	HRP	1.2
AXLE U-BOLT PLATE	STEEL	10.0	HRP	4.0
STEERING GEAR HOUSING	IRON	15.5	ALUM	7.8
MASTER CYLINDER	IRON	10.2	ALUM	5.1
BRAKE & CLUTCH PEDAL	STEEL	6.0	HRP	2.4
PARKING BRAKE PEDAL & BRACKET	STEEL	4.0	HRP	1.6
DRIVE SHAFT	STEEL	24.0	HRP	9.6
WHEEL	STEEL	107.5	HRP	43.0
FUEL TANK	TERNE	24.0	HDPE	15.5
RADIATOR	COPPER	14.0	ALUM	7.0
HEATER CORE	COPPER	5.0	ALUM	2.5
WINDSHIELD	GLASS	31.0	GLASS	24.8
REAR WINDOW	GLASS	18.0	GLASS	12.0
DOOR GLASS	GLASS	16.0	GLASS	10.7
SIDE WINDOW	GLASS	35.0	GLASS	23.3
BRAKE DISC	IRON	55.5	ALUM	27.8
BRAKE DRUM	IRON	26.0	ALUM	13.0
BATTERY TRAY	STEEL	3.0	HRP	1.5
CYLINDER HEAD	IRON	74.0	ALUM	37.0
ENGINE BLOCK	IRON	145.0	ALUM	72.5
INTAKE MANIFOLD	IRON	35.6	ALUM	17.8
EXHAUST MANIFOLD	IRON	24.9	STAINLESS STEEL	9.4
AIR CLEANER HOUSING	STEEL	6.0	HRP	3.0
VALVE COVER	STEEL	6.5	HRP	3.3
OIL PAN	STEEL	7.5	HRP	3.8
WATER PUMP	IRON	7.5	ALUM	3.8
CONNECTING ROD	STEEL	10.0	HRP	4.0

APPENDIX C

VEHICULAR DATA FOR AUTOMOBILES AND LIGHT TRUCKS

This appendix summarizes acceleration performance and other vehicular data from track tests reported in the popular automotive literature for 1978 passenger cars and light trucks.

TABLE C-1 ACCELERATION PERFORMANCE AND OTHER VEHICLE DATA FOR 1978 PASSENGER CARS

MODEL	CID	HP	TORQUE	TRANSMISSION	AXLE RATIO	INERTIA WT (LBS.)	0-60 MPH (SEC.)
PORSCHE TURBO	201	261	291	M4	4.22	3144	4.9
PORSCHE 911SC	183	172	189	M5	3.88	2930	5.5
PORSCHE 911 SC	183	172	189	M5	3.88	3040	6.3
PORSCHE 928	273	219	254	M5	2.75	3720	6.4
CORVETTE	350	220	260	M4	3.70	3790	6.5
PORSCHE 928	273	219	254	M5	2.75	3710	7.0
PONTIAC TRANS AM WS6	400	220	320	M4	3.42	4020	7.2
CAMARO Z28	350	185	280	M4	3.73	3860	7.3
FERRARI 308GTS	179	205	181	M5	3.71	3605	7.3
CHEVROLET CORVETTE L82	350	220	260	M4	3.70	3790	7.4
CORVETTE	350	185	280	A3	3.08	3949	7.8
CHEVROLET CAMARO Z-28	350	185	280	M4	3.73	3860	7.9
PORSCHE 928	273	219	254	M5	2.75	3437	8.2
PORSCHE 911S	164	157	168	M5	3.88	2860	8.2
MERCEDES-BENZ 450 SEL 6.9	417	250	360	A3	2.65	4870	8.3
JAGUAR XJ12L	326	244	269	A3	3.31	4570	8.6
LOTUS ECLAT	120	140	130	M5	4.10	2460	8.7
LOTUS ESPRIT 52	120	140	130	M5	4.38	2280	8.7
JAGUAR XJ12L	326	244	269	A3	3.31	4565	8.8
BMW 733I	196	177	196	M4	3.45	3830	8.8
VOLVO 240 TURBO	130	175	190	M4	3.91	3435	8.8
OLDSMOBILE 4.42	305	160	235	A3	2.56	3740	8.9
MASERATI MERAK /SS	181	182	180	M5	4.38	3485	9.1
RX-7	70	100	105	M5	3.91	2720	9.2
FAIRMOUNT	302	137	245	A3	2.45	3331	9.4
SAAB TURBO	121	135	160	M4	3.89	2985	9.5
SAAB TURBO	121	135	160	M4	3.89	2967	9.5
ZEPHYR Z7	302	139	250	A3	2.47	3470	9.9
MONTE CARLO	305	145	245	A3	2.56	3780	10.0
GRAND PRIX	302	141	240	A3	2.73	3780	10.1
ALFA ROMEO SPRINT VELOCE	120	111	122	M5	4.10	2960	10.1
DATSUN 280Z	168	149	163	M5	3.55	3083	10.2

TABLE C-1 (CONT'D)

MODEL	CID	HP	TORQUE	TRANSMISSION	AXLE RATIO	INERTIA WT (LBS.)	0-60 MPH (SEC.)
MAZDA RX-7 ROTARY	70	100	105	M5	3.90	2650	10.3
CONCORD DL	304	120	200	A3	2.87	3850	10.4
ALFA ROMEO SPIDER VELOCE	120	111	122	M5	4.56	2810	10.4
CELICA	134	95	122	M5	3.73	2805	10.4
SCIROCCO	89	71	73	M4	3.90	2250	10.4
SAAB 99 TUNBO	121	135	160	M4	3.89	2993	10.8
SCIROCCO	89	71	73	A4	3.90	2135	10.8
BMW 733I	196	177	196	M4	3.45	4100	10.9
MALIBU CLASSIC	305	145	245	A3	2.56	3700	10.9
LE BARON	318	145	245	A3	2.71	4130	11.0
SAAB 99 TURBO EMS	121	135	160	M4	3.89	2970	11.0
LOTUS ELITE	120	140	130	A3	4.10	2460	11.0
DODGE MAGNUM XE	400	190	305	A3	2.40	4612	11.1
VOLVO 262C	162	125	150	M4	3.73	3420	11.1
ALFA ROMEO SPRINT VELOCE	120	111	122	M5	4.10	2910	11.1
REGAL SPORT	231	175	265	A3	2.73	3802	11.2
PONTIAC GRAND AM CA	305	190	255	M4	3.23	3765	11.2
TRIUMPH TR7	122	86	103	M5	3.90	2770	11.2
PORSCHE 924	121	110	111	M4	3.88	2750	11.2
VERSAILLES	351	135	275	A3	2.50	4270	11.3
PONTIAC GRAND LE MANS	305	145	245	A3	2.29	3719	11.3
VOLVO 242GT	130	101	111	M4	3.91	3230	11.3
BUICK ELECTRA 225	350	170	275	A3	2.41	4750	11.4
MALIBU	305	135	240	A3	2.73	3775	11.4
CRESSIDA	165	108	134	A4	3.91	3090	11.4
DATSUN 510	119	97	102	M5	3.55	2525	11.4
GRAND AMC	302	141	240	A3	2.73	3771	11.5
CELICA GT	134	95	122	M5	3.59	2775	11.5
CRESSIDA	156	108	134	A4	3.91	3030	11.6
LINCOLN CONTINENTAL MARK	402	181	331	A3	2.50	5190	11.7
CHEVROLET MONTE CARLO	305	101	325	A3	2.73	3724	11.7
HORIZON	105	75	90	M3	3.48	2470	11.7

TABLE C-1 (CONT'D)

MODEL	CID	HP	TORQUE	TRANSMISSION	AXLE RATIO	INERTIA WT (LBS.)	0-60 MPH (SEC.)
CELICA LB	133	95	122	M5	3.58	2790	11.8
BUICK TURBO SKYHAWK	231	171	212	M5	2.93	3135	11.9
AUDI 5000	131	103	110	M4	4.11	3014	12.0
SAPPORO	156	105	139	M5	3.30	3040	12.1
FIAT 124 SPORT SPIDER	107	86	90	M5	4.30	2600	12.1
BMW 320I	121	110	112	M4	3.64	2950	12.3
FIAT X1/9	79	62	67	M4	4.42	2390	12.3
BUICK/OPEL SPORT COUPE	111	80	95	M5	3.31	2470	12.5
ACCORD LX	98	68	85	M5	4.27	2350	12.6
MERCEDES-BENZ 300 SD	183	110	168	A4	3.07	4188	12.7
DATSUN 510	119	97	102	M5	3.55	2680	12.7
BUICK CENTURY CUSTOM WAGO	305	108	332	A3	2.41	3614	12.8
AUDI 5000	131	103	110	A3	3.90	3160	12.9
FIAT 131 SUPER BRAVA	107	86	90	M5	4.10	2755	13.0
CHEVROLET MALIBU CLASSIC	305	108	332	A3	2.41	3590	13.2
MERCEDES 300 SD TURBO-DIE	183	110	168	A4	3.07	4190	13.5
AUDII 5000	131	103	110	A3	3.90	3150	13.5
CHALLENGER	156	105	139	M5	3.31	3064	13.6
ACCORD XL	98	68	85	M5	4.21	2390	13.8
MERCEDES-BENZ 280CE COUPE	168	142	149	A4	3.54	3710	13.9
MERCURY V-6 BOBCAT	171	90	143	A3	3.40	2904	14.0
TRIUMPH TR7	122	86	103	M5	3.90	2778	14.0
HORIZON	105	70	85	M4	3.48	2650	14.0
TOYOTA COROLLA SR-5	97	73	83	M5	4.10	2580	14.1
DATSUN 510 HATCH BACK	119	94	102	M5	3.55	2540	14.2
ALFA ROMEO SPIDER	120	110	121	M5	4.50	2850	14.3
FAIRMOUNT	140	88	118	M4	3.08	3050	14.5
PONTIAC GRAND LE MANS SAF	305	108	332	A3	2.41	3612	14.6
VW SCIROCCO SIDEWINDER II	89	71	73	M4	3.90	2248	14.6
OLDSMOBILE CUTLASS WAGON	305	108	332	A3	2.41	3606	14.7
DODGE CHALLENGER	156	105	139	M5	3.30	2998	14.7
DELTA 88 ROYALE	350	120	220	A3	2.41	4461	14.9

TABLE C-1 (CONT'D)

MODEL	CID	HP	TORQUE	TRANSMISSION	AXLE RATIO	INERTIA WT (LBS.)	0-60 MPH (SEC.)
HONDA ACCORD LX	98	68	85	M5	4.43	2377	15.2
MERCURY ZEPHYR ESO	140	92	121	M4	3.08	3155	15.8
CHEVROLET CHEVETTE (4 DOO	98	63	82	M4	3.70	2471	15.8
OLDS DELTA 88 DIESEL	350	120	220	A3	2.41	4372	16.5
FORD FAIRMONT ESO	200	85	154	A3	3.08	3085	16.6
PORSCHE 924	260	110	205	A3	2.29	3662	16.8
OLDSMOBILE CUTLASS SUPER	260	82	278	A3	2.29	3662	16.8
VOLKSWAGEN BEETLE CONVERT	97	48	73	M4	3.88	2420	17.0
MAZDA GLC SPORT	78	49	63	M5	3.73	2319	17.0
RENAULT LE CAR R5 GTL	79	60	70	M4	3.74	2105	17.1
PEUGEOT 504D	141	71	99	A3	3.78	3290	21.6
MERCEDES-BENZ 300D	183	77	115	A4	3.46	3850	21.7
MERCEDES-BENZ 300CD	183	77	115	A4	3.46	3795	21.7
PEUGEOT 504 DIESEL AUTOMA	141	71	99	A3	3.78	3465	21.7

TABLE C-2 ACCELERATION PERFORMANCE AND OTHER VEHICLE DATA FOR 1978 LIGHT TRUCKS

MODEL	CID	HP	TORQUE	TRANSMISSION	AXLE RATIO	INERTIA WT (LBS.)	0-60 MPH (SEC.)
PLYMOUTH TRAIL DUSTER	440	220	330	A3	3.55	5290	10.1
CHEVROLET EL CAMINO	350	170	270	A3	2.73	3775	10.1
CHEVY BEAUVILLE SPORTVAN	400	175	290	A3	2.76	4860	10.9
CHEVROLET CARAVAN	400	175	290	A3	3.40	4910	11.3
JEEP CJ-7	304	150	245	A3	3.54	3640	11.4
GMC DIABLO PICKUP	350	170	270	M4	2.73	3750	11.6
INTERNATIONAL SCOUT SSII	345	163	292	A3	3.73	4320	11.7
DODGE D-100 PICKUP	318	145	250	M4	3.20	4090	11.8
FORD BRONCO	400	169	303	M4	3.50	5510	12.0
CHEVY K-30 PICKUP	400	175	290	A3	5.56	5650	12.1
JEEP J-10	360	195	295	M4	3.54	4660	12.6
CHEVY K-10 PICKUP	400	175	290	A3	3.40	5065	12.8
FORD F-150 PICKUP	351	163	267	A3	4.11	5040	13.0
FORD F-250 PICKUP	400	169	303	A3	4.10	5550	14.0
JEEP J-20	360	175	285	A3	3.73	4970	14.1
CHEVROLET SUBURBAN K-20	400	175	290	A3	3.73	5810	14.3
CHEVROLET LUV SERIES 6	111	80	95	M4	4.10	2870	15.8
SUBARU BRAT	97	65	80	M4	3.89	2445	16.1
FORD E-150 ECONOLINE VAN	300	120	229	M4	3.00	4620	16.3
TOYOTA LAND CRUISER	258	125	200	M4	4.11	4650	17.5

APPENDIX D

This appendix presents results of an analysis conducted by ALCOA under contract No. TS-14318, "Non-passenger Vehicle (NPA) Weight Reduction by Aluminum Substitution." Two hypothetical vehicles representing pickup trucks and vans in the 6000 GVW class were used in the analyses. The conservative analysis considers gauge increase while the optimum analysis considers gauge-to-gauge substitution

TABLE D-1 HYPOTHETICAL TRUCK - CONSERVATIVE ANALYSIS

PART NAME	NUMBER OF PIECES	MATERIAL	ALLOY	STEEL BLANK WEIGHT	STEEL PART WEIGHT	ALUMINUM BLANK WEIGHT	ALUMINUM PART WEIGHT	WEIGHT SAVED	NET AL USED/ VEHICLE
AIR CLEANER BODY	1	TERNE	5182	4.00	3.00	1.77	1.30	1.70	1.30
AIR CLEANER COVER	1	TERNE	5182	2.00	1.50	0.88	0.65	0.85	0.65
BATTERY TRAY	1	GALV. CRS	5182	2.00	1.50	1.03	0.75	0.75	0.75
BUMPER FRONT	1	SAE 950	7146	37.50	30.00	19.15	15.02	14.98	15.02
BUMPER REAR STD.	1	SAE950	7146	30.00	24.00	15.32	12.01	11.99	12.01
BUMPER REAR STEP OPT	1	CRS	5252	75.00	71.00	40.98	38.04	32.96	38.04
CARGO BOX CROSS SILL	5	GALV CRS	6010	50.00	40.00	27.32	21.43	18.57	21.43
CARGO BOX FRONT PNL	1	CRS	6010	19.00	17.00	8.24	7.23	9.77	7.23
CARGO BOX CORNER PIL	2	ZINCROMET	6009	11.00	8.00	5.64	4.02	3.98	4.02
CARGO BOX INNER PNL	2	GALV CRS	6010	87.00	70.00	38.03	30.00	40.00	30.00
CARGO BOX OUTER PNL	2	ZINCROMET	6010	92.50	74.00	40.44	31.71	42.29	31.71
CARGO BOX WHEEL HSE	2	GALV CRS	6009	20.00	16.00	8.81	6.91	9.09	6.91
CARGO BOX TAIL GATE	1	ZINCROMET	6009	50.00	43.00	27.53	23.21	19.79	23.21
CARGO BOX BRACKETS	2	CRS	6009	5.00	4.50	2.54	2.23	2.26	2.24
CARGO BOX LOAD FLOOR	1	HRS	6009	87.00	78.00	47.54	41.79	36.21	41.79
COWL PANEL INNER	1	GALV CRS	6009	8.60	6.00	3.74	2.56	3.44	2.56
COWL PANEL OUTER	1	ZINCROMET	6009	16.25	13.00	7.16	5.61	7.39	5.61
DASH PANEL	1	ZINCROMET	5182	26.00	17.00	11.30	7.25	9.75	7.25
DOOR INNER PANEL	2	CRS	6009	53.00	32.00	23.04	13.64	18.36	13.64
DOOR OUTER PANEL	2	ZINCROMET	6010	44.30	31.00	19.26	13.21	17.79	13.21
FENDER FRONT	2	ZINCROMET	6009	35.40	23.00	15.39	9.80	13.20	9.80
FLOOR PAN CAB	1	CRS	5182	57.00	40.00	28.84	19.84	20.16	19.84
FUEL TANK	1	TERNE	5182	27.00	21.00	11.66	8.89	12.11	8.89
HEATER CORE	1	CU BRASS		0.00	4.50	0.00	1.50	3.00	1.50
HOOD INNER PANEL	1	ZINCROMET	6009	40.00	26.00	17.39	11.08	14.92	11.08
HOOD OUTER PANEL	1	ZINCROMET	6010	45.00	36.00	19.57	15.35	20.65	15.35
RADIATOR	1	CU BRASS		0.00	20.00	0.00	10.00	10.00	10.00
RADIATOR SUPPORT ASY	1	GALV CRS	5182	45.00	35.00	22.95	17.50	17.50	17.50
ROOF CAB OUTER PNL	1	CRS	6010	27.00	22.00	11.74	9.38	12.62	9.38
ROOF CAB INNER PNL	1	CRS	6009	24.00	19.00	10.44	8.10	10.90	8.10
SEAT FRAME	1	CRS	6009	10.00	9.00	5.10	4.50	4.50	4.50
SPARE TIRE CARRIER	1	CRS	6010	10.00	9.00	4.38	3.87	5.13	3.87
VALVE COVER	2	CRDQSK	5182	10.00	6.00	4.37	2.57	3.43	2.57
WHEELS	5	HRS	5454	150.00	140.00	81.96	75.00	65.00	75.00
TOTAL								482.08	437.92

NOTE: ABOVE TOTALS DO NOT INCLUDE THE OPTIONAL REAR STEP BUMPER

TABLE D-2 HYPOTHETICAL TRUCK - OPTIMUM ANALYSIS

PART NAME	NUMBER OF PIECES	MATERIAL	ALLOY	STEEL BLANK WEIGHT	STEEL PART WEIGHT	ALUMINUM BLANK WEIGHT	ALUMINUM PART WEIGHT	WEIGHT SAVED	NET AL USED/ VEHICLE
AIR CLEANER BODY	1	TERNE	5182	4,00	3,00	1,46	1,07	1,93	1,07
AIR CLEANER COVER	1	TERNE	5182	2,00	1,50	0,73	0,54	0,96	0,54
BATTERY TRAY	1	GALV. CRS	5182	2,00	1,50	0,88	0,64	0,86	0,64
BUMPER FRONT	1	SAE 950	7146	37,50	30,00	16,35	12,82	17,18	12,82
BUMPER REAR STD.	1	SAE950	7146	30,00	24,00	13,08	10,26	13,74	10,26
BUMPER REAR STEP OPT	1	CRS	5252	75,00	71,00	38,36	35,60	35,40	35,60
CARGO BOX CROSS SILL	5	GALV CRS	6010	50,00	40,00	25,57	20,05	19,95	20,05
CARGO BOX FRONT PNL	1	CRS	6010	19,00	17,00	6,92	6,07	10,93	6,07
CARGO BOX CORNER PIL	2	ZINCROMET	6009	11,00	8,00	4,82	3,44	4,56	3,44
CARGO BOX INNER PNL	2	GALV CRS	6010	87,00	70,00	31,69	25,00	45,00	25,00
CARGO BOX OUTER PNL	2	ZINCROMET	6010	92,50	74,00	33,70	26,43	47,57	26,43
CARGO BOX WHEEL HSE	2	GALV CRS	6009	20,00	16,00	7,29	5,71	10,29	5,71
CARGO BOX TAIL GATE	1	ZINCROMET	6009	50,00	43,00	25,42	21,43	21,57	21,43
CARGO BOX BRACKETS	2	CRS	6009	5,00	4,50	2,20	1,94	2,56	1,94
CARGO BOX LOAD FLOOR	1	HRS	6009	87,00	78,00	44,60	39,21	38,79	39,21
COWL PANEL INNER	1	GALV CRS	6009	8,60	6,00	3,13	2,14	3,86	2,14
COWL PANEL OUTER	1	ZINCROMET	6009	16,25	13,00	5,92	4,64	8,36	4,64
DASH PANEL	1	ZINCROMET	5182	26,00	17,00	9,47	6,07	10,93	6,07
DOOR INNER PANEL	2	CRS	6009	53,00	32,00	19,31	11,43	20,57	11,43
DOOR OUTER PANEL	2	ZINCROMET	6010	44,30	31,00	16,14	11,07	19,93	11,07
FENDER FRONT	2	ZINCROMET	6009	35,40	23,00	12,90	8,21	14,79	8,21
FLOOR PAN CAB	1	CRS	5182	57,00	40,00	24,80	17,06	22,94	17,06
FUEL TANK	1	TERNE	5182	27,00	21,00	9,84	7,50	13,50	7,50
HEATER CORE	1	CU BRASS		0,00	4,50	0,00	1,50	3,00	1,50
HOOD INNER PANEL	1	ZINCROMET	6009	40,00	26,00	14,57	9,29	16,71	9,29
HOOD OUTER PANEL	1	ZINCROMET	6010	45,00	36,00	16,39	12,86	23,14	12,86
RADIATOR	1	CU BRASS		0,00	20,00	0,00	10,00	10,00	10,00
RADIATOR SUPPORT ASY	1	GALV CRS	5182	45,00	35,00	19,67	15,00	20,00	15,00
ROOF CAB OUTER PNL	1	CRS	6010	27,00	22,00	9,84	7,86	14,14	7,86
ROOF CAB INNER PNL	1	CRS	6009	24,00	19,00	8,74	6,79	12,21	6,79
SEAT FRAME	1	CRS	6009	10,00	9,00	4,37	3,86	5,14	3,86
SPARE TIRE CARRIER	1	CRS	6010	10,00	9,00	3,64	3,21	5,79	3,21
VALVE COVER	2	CRDQSK	5182	10,00	6,00	3,64	2,14	3,86	2,14
WHEELS	5	HRS	5454	150,00	140,00	76,50	70,00	70,00	70,00
TOTAL								534.76	385.24

NOTE: ABOVE TOTALS DO NOT INCLUDE THE OPTIONAL REAR STEP BUMPER

TABLE D-3 HYPOTHETICAL VAN - CONSERVATIVE ANALYSIS

PART NAME	NUMBER OF PIECES	MATERIAL	ALLOY	STEEL BLANK WEIGHT	STEEL PART WEIGHT	ALUMINUM BLANK WEIGHT	ALUMINUM PART WEIGHT	WEIGHT SAVED	NET AL USED/ VEHICLE
AIR CLEANER BODY	1	TERNE	5182	4,00	3,00	1,77	1,30	1,70	1,30
AIR CLEANER COVER	1	TERNE	5182	2,00	1,50	0,88	0,65	0,85	0,65
BATTERY TRAY	1	CRS	5182	3,00	2,70	1,54	1,36	1,34	1,36
BUMPER FRONT	1	SAE 950	7146	39,00	31,00	19,91	15,52	15,48	15,52
BUMPER REAR	1	SAE 950	7146	30,00	24,00	15,32	12,01	11,99	12,01
COWL PANEL INNER	1	CRS	6009	17,10	12,00	7,44	5,12	6,88	5,12
COWL PANEL OUTER	1	CRS	6009	16,25	13,00	7,07	5,55	7,45	5,55
DASH PANEL	1	CRS	5182	18,50	13,50	8,14	5,83	7,67	5,83
DOOR FRONT INNER	2	CRS	6009	57,00	37,00	24,78	15,77	21,23	15,77
DOOR FRONT OUTER	2	CRS	6010	44,00	33,00	19,13	14,07	18,93	14,07
DOOR BODYSIDE FR IN	1	CRS	6009	21,70	13,00	9,44	5,54	7,46	5,54
DOOR BODYSIDE FR OUT	1	CRS	6010	20,00	14,00	8,70	5,97	8,03	5,97
DOOR BODYSIDE R IN	1	CRS	6009	21,70	13,00	9,44	5,54	7,46	5,54
DOOR BODYSIDE R OUT	1	CRS	6010	20,00	14,00	8,70	5,97	8,03	5,97
DOOR REAR RH INSIDE	1	CRS	6009	21,00	12,00	9,13	5,12	6,88	5,12
DOOR REAR RH OUTSIDE	1	CRS	6010	20,00	13,00	8,70	5,54	7,46	5,54
DOOR REAR LH INSIDE	1	CRS	6009	21,00	12,00	9,13	5,12	6,88	5,12
DOOR REAR LH OUTSIDE	1	UCRS	6010	20,00	13,00	8,70	5,54	7,46	5,54
FUEL TANK	1	TERNE	5182	27,00	21,00	11,66	8,89	12,11	8,89
FENDER ASSMLY FRONT	2	CRS	6009	34,30	24,00	14,91	10,23	13,77	10,23
HEATER CORE	1	CU BRASS		0,00	4,50	0,00	1,50	3,00	1,50
HOOD INNER PANEL	1	CRS	6009	18,50	12,00	8,18	5,20	6,80	5,20
HOOD OUTER PANEL	1	CRS	6010	20,00	16,00	8,70	6,82	9,18	6,82
RADIATOR	1	CU BRASS		0,00	20,00	0,00	10,00	10,00	10,00
RADIATOR SUPPORT	1	CRS	6009	33,00	23,00	16,70	11,41	11,59	11,41
ROOF PANEL	1	CRS	6010	88,90	80,00	39,25	34,63	45,37	34,63
ROOF BOWS	4	CRS	6010	17,50	14,00	8,85	6,94	7,06	6,94
SEAT FRAMES	2	CRS	6010	20,00	16,00	10,23	8,03	7,97	8,03
VALVE COVERS	2	CRDQSK	5182	10,00	6,00	4,37	2,57	3,43	2,57
WHEELS	5	HRS	5454	150,00	140,00	81,96	75,00	65,00	75,00
FLOOR PAN	1	CRS	6010	88,90	80,00	45,14	39,83	40,17	39,83
TOTAL								388.63	342.57

TABLE D-4 HYPOTHETICAL VAN - OPTIMUM ANALYSIS

PART NAME	NUMBER OF PIECES	MATERIAL	ALLOY	STEEL BLANK WEIGHT	STEEL PART WEIGHT	ALUMINUM BLANK WEIGHT	ALUMINUM PART WEIGHT	WEIGHT SAVED	NET AL USED/ VEHICLE
AIR CLEANER BODY	1	TERNE	5182	4,00	3,00	1,46	1,07	1,93	1,07
AIR CLEANER COVER	1	TERNE	5182	2,00	1,50	0,73	0,54	0,96	0,54
BATTERY TRAY	1	CRS	5182	3,00	2,70	1,32	1,16	1,54	1,16
BUMPER FRONT	1	SAE 950	7146	39,00	31,00	17,00	13,25	17,75	13,25
BUMPER REAR	1	SAE 950	7146	30,00	24,00	13,08	10,26	13,74	10,26
COWL PANEL INNER	1	CRS	6009	17.10	12,00	6,23	4,29	7,71	4,29
COWL PANEL OUTER	1	CRS	6009	16,25	13,00	5,92	4,64	8,36	4,64
DASH PANEL	1	CRS	5182	18,50	13,50	6,74	4,82	8,68	4,82
DOOR FRONT INNER	2	CRS	6009	57,00	37,00	20,76	13,21	23,79	13,21
DOOR FRONT OUTER	2	CRS	6010	44,00	33,00	16,03	11,79	21,21	11,79
DOOR BODYSIDE FR IN	1	CRS	6009	21,70	13,00	7,90	4,64	8,36	4,64
DOOR BODYSIDE FR OUT	1	CRS	6010	20,00	14,00	7,29	5,00	9,00	5,00
DOOR BODYSIDE R IN	1	CRS	6009	21,70	13,00	7,90	4,64	8,36	4,64
DOOR BODYSIDE R OUT	1	CRS	6010	20,00	14,00	7,29	5,00	9,00	5,00
DOOR REAR RH INSIDE	1	CRS	6009	21,00	12,00	7,65	4,29	7,71	4,29
DOOR REAR RH OUTSIDE	1	CRS	6010	20,00	13,00	7,29	4,64	8,36	4,64
DOOR REAR LH INSIDE	1	CRS	6009	21,00	12,00	7,65	4,29	7,71	4,29
DOOR REAR LH OUTSIDE	1	UCRS	6010	20,00	13,00	7,29	4,64	8,36	4,64
FUEL TANK	1	TERNE	5182	27,00	21,00	9,84	7,50	13,50	7,50
FENDER ASSMLY FRONT	2	CRS	6009	34,30	24,00	12,50	8,57	15,43	8,57
HEATER CORE	1	CU BRASS		0,00	4,50	0,00	1,50	3,00	1,50
HOOD INNER PANEL	1	CRS	6009	18,50	12,00	6,74	4,29	7,71	4,29
HOOD OUTER PANEL	1	CRS	6010	20,00	16,00	7,29	5,71	10,29	5,71
RADIATOR	1	CU BRASS		0,00	20,00	0,00	10,00	10,00	10,00
RADIATOR SUPPORT	1	CRS	6009	33,00	23,00	14,36	9,81	13,19	9,81
ROOF PANEL	1	CRS	6010	88,90	80,00	32,38	29,57	51,43	28,57
ROOF BOWS	4	CRS	6010	17,50	14,00	7,61	5,97	8,03	5,97
SEAT FRAMES	2	CRS	6010	20,00	16,00	8,67	6,80	9,20	6,80
VALVE COVERS	2	CRDQSK	5182	10,00	6,00	3,64	2,14	3,86	2,14
WHEELS	5	HRS	5454	150,00	140,00	76,50	70,00	70,00	70,00
FLOOR PAN	1	CRS	6010	88,90	80,00	39,25	34,63	45,37	34,63
TOTAL								433.54	297.46

APPENDIX E
FUNCTIONAL GROUP WEIGHTS

This appendix presents functional group weights for 13 1974 GM models. Data contained in this appendix were submitted by General Motors.[26]

TABLE E-1 FUNCTIONAL GROUP WEIGHTS FOR 1974 MODELS
(PART 1 OF 3)

(ALL WEIGHTS ARE IN LBS.)

FUNCTIONAL GROUPS	CHEVROLET 1974 'H' 2-DR. COUPE	CHEVROLET 1974 'X' 4-DR. SEDAN	CHEVROLET 1974 'A' 4-DR. SEDAN	PONTIAC 1974 'A' 4-DR. SEDAN	BUIC[illegible] 1974 4-DR. [illegible]
STRUCTURE	549	680	933	908	966
BODY	522	467	482	473	487
FRAME	3	103	324	321	318
FRONT SHEET METAL	24	110	127	114	161
POWERTRAIN	774	1192	1198	1243	1244
ENGINE	270	539	534	623	566
STARTING SYSTEM	49	68	69	57	73
TRANSMISSION	173	181	178	162	177
DRIVELINE	101	126	136	136	147
FUEL SYSTEM	122	159	171	171	170
EXHAUST SYSTEM	28	48	46	37	45
COOLING SYSTEM	31	71	64	57	70
FRONT SUSPENSION	68	109	119	120	129
REAR SUSPENSION	63	131	84	87	84
BRAKE SYSTEM	88	123	141	141	138
FRONT BRAKES	43	57	72	74	71
REAR BRAKES	29	47	46	48	48
APPLY SYSTEM	16	19	23	19	19
STEERING SYSTEM	28	72	60	76	65
TIRES	91	102	111	120	129
WHEELS	75	84	104	99	99
BUMPERS	111	189	235	224	227
FRONT	66	110	122	121	128
REAR	51	79	113	103	99
NON-WEIGHT DEPENDENT* FUNCTIONAL SUBSYSTEMS	663	825	1041	982	951
CURB MASS	2510	3507	4026	4000	4032
GVW	3368	4709	5283	5142	5298
FRONT	1604	2231	2632	2442	2655
REAR	1764	2478	2651	2700	2643

* AS DESCRIBED IN INFORMATION PREVIOUSLY SUBMITTED (ATTACHMENT 'A' OF USG 1794, PART III).

TABLE E-1 FUNCTIONAL GROUP WEIGHTS FOR 1974 MODELS (PART 2 OF 3)

(ALL WEIGHTS ARE IN LBS.)

FUNCTIONAL GROUPS	OLDSMOBILE 1974 'A' 4-DR. SEDAN	CHEVROLET 1974 'B' 4-DR. SEDAN	PONTIAC 1974 'B' 4-DR. SEDAN	BUICK 1974 "B' 4-DR. SEDAN	OLDSMOBI 1974 'B 4-DR. SEC
STRUCTURE	921	1097	1084	1098	1099
BODY	456	585	573	575	560
FRAME	319	373	379	378	378
FRONT SHEET METAL	146	139	132	145	161
POWERTRAIN	1264	1259	1375	1300	1337
ENGINE	592	532	623	570	586
STARTING SYSTEM	65	69	59	73	66
TRANSMISSION	174	180	198	181	198
DRIVELINE	145	149	170	152	167
FUEL SYSTEM	171	199	203	199	199
EXHAUST SYSTEM	43	50	47	47	45
COOLING SYSTEM	74	80	75	78	76
FRONT SUSPENSION	127	131	131	131	142
REAR SUSPENSION	81	89	85	93	98
BRAKE SYSTEM	135	177	185	183	172
FRONT BRAKES	72	86	89	88	81
REAR BRAKES	47	60	60	62	59
APPLY SYSTEM	16	31	36	33	32
STEERING SYSTEM	69	69	68	66	72
TIRES	119	136	131	141	141
WHEELS	100	113	113	110	111
BUMPERS	230	233	229	274	255
FRONT	141	114	110	143	133
REAR	89	119	119	131	122
NON-WEIGHT DEPENDENT* FUNCTIONAL SUBSYSTEMS	1020	1066	1086	1040	1110
CURB MASS	4066	4370	4487	4436	4537
GVW	5340	5625	5740	5695	5834
FRONT	2667	2721	2786	2763	2816
REAR	2673	2904	2954	2932	3018

* AS DESCRIBED IN INFORMATION PREVIOUSLY SUBMITTED (ATTACHMENT 'A' OF USG 1794, PART III).

TABLE E-1 FUNCTIONAL GROUP WEIGHTS FOR 1974 MODELS
(PART 3 OF 3)

(ALL WEIGHTS ARE IN LBS.)

FUNCTIONAL GROUPS	BUICK 1974 'C' 4-DR. SEDAN	OLDSMOBILE 1974 'C' 4-DR. SEDAN	CADILLAC 1974 'C' 4-DR. SEDAN		
STRUCTURE	1218	1215	1333		
BODY	657	636	720		
FRAME	416	413	438		
FRONT SHEET METAL	145	166	175		
POWERTRAIN	1440	1406	1503		
ENGINE	643	634	678		
STARTING SYSTEM	82	74	73		
TRANSMISSION	200	198	203		
DRIVELINE	180	170	185		
FUEL SYSTEM	201	198	205		
EXHAUST SYSTEM	56	56	72		
COOLING SYSTEM	78	76	87		
FRONT SUSPENSION	132	143	127		
REAR SUSPENSION	83	94	101		
BRAKE SYSTEM	195	184	203		
FRONT BRAKES	88	81	87		
REAR BRAKES	74	72	79		
APPLY SYSTEM	33	31	37		
STEERING SYSTEM	67	72	70		
TIRES	146	147	157		
WHEELS	110	111	115		
BUMPERS	269	263	259		
FRONT	143	133	133		
REAR	126	130	126		
NON-WEIGHT DEPENDENT* FUNCTIONAL SUBSYSTEMS	1141	1263	1310		
CURB MASS	4801	4898	5178		
GVW	6171	6289	6516		
FRONT	2990	2998	3196		
REAR	3181	3291	3320		

* AS DESCRIBED IN INFORMATION PREVIOUSLY SUBMITTED (ATTACHMENT 'A' OF USG 1794, PART III).

APPENDIX F

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