INTRODUCTION

This guide is furnished as an aid to final stage manufacturers in determining conformity to the applicable Emission Control and Federal Motor Vehicle Safety Standards. Final stage manufacturers should maintain current knowledge of all Emission Regulations and Federal Motor Vehicle Safety Standards and be aware of their specific responsibility in regards to each standard.

Any manufacturer making material alterations to this incomplete vehicle during the process of manufacturing the completed vehicle should be constantly alert to all effects, direct or indirect, on other components, assemblies or systems caused by such alterations. No alterations should be made to the incomplete vehicle which either directly or indirectly results in any component, assembly or system being in nonconformance with applicable Emission Regulations or Federal Motor Vehicle Safety Standards.

GM/American Isuzu Motors, Inc. will honor its warranty commitment (for the cab-chassis ***only***), to the ultimate consumer, provided: (1) the final stage manufacturer has not made any alterations or modifications which do not conform to any applicable laws, regulations or standards, or adversely affect the operation of the cab-chassis; and (2) the final stage manufacturer complied with the instructions contained in this guide with respect to the completion of the vehicle. Otherwise, the warranty becomes the responsibility of the final stage manufacturer.

The final stage manufacturer is solely responsible for the final certification of the vehicle and for compliance with Emission Control and Motor Vehicle Safety standards. The information contained in this guide is furnished for the final stage manufacturer's information and guidance.

This guide contains information pertaining to the GM/Isuzu built W3500 Gas, W3500 Diesel, W4500 Gas, W4500 Diesel, W5500 Diesel.

NOTE: All information and specifications contained in this book are based on the latest information available at the time of the publication. The manufacturer reserves the right to discontinue or change, at any time, without prior notice, specifications, options, materials, equipment, design and models.

GENERAL INFORMATION

The following is a list of Federal Motor Vehicle Safety Standards applicable to those vehicles with a GVWR greater than 10,000 lbs. Please refer to the following chart.

FMVSS	Title	W3500 W4500	W5500	FMVSS	Title	W3500 W4500	W5500
101	Controls and Displays	A+	A+	118	Power Operated Window System[5]	A	A
102	Transmission Shift Lever, Sequence Starter Interlock, and Transmission Braking Effect.	A+	A+	120	Tire Selection and Rims	A+	A+
103	Windshield Defrosting and Defogging Systems	A+	A+	121	Air Brake Systems	B	B
104	Windshield Wiping and Washing Systems	A+	A+	124	Accelerator Control Systems	A+	A+
105	Hydraulic Brake Systems	A+	A+	205	Glazing Materials	A+	A+
106	Brake Hoses	A+	A+	206	Door Locks and Door Retention Components	A+	A+
107	Reflecting Surfaces	A+	A+	207	Seating Systems	A+	A+
108	Lamps, Reflective Devices, and Associated Equipment	A+	A+	208	Occupant Crash Protection	A+	A+
111	Rear View Mirrors	A+	A+	209	Seat Belt Assemblies	A+	A+
112	Headlamp Concealment Devices	A	A	210	Seat Belt Assembly Anchorages	A+	A+
113	Hood Latch System	A	A	211	Wheel Nuts, Wheel Discs, and Hub Caps[4]	A	A
115	Vehicle Identification Number	A	A	213	Child Restraint Systems	A	A
116	Motor Vehicle Brake Fluids	A+	A+	302	Flammability of Interior Materials	A+	A+

This chart is only a guide. For complete information, please refer to "Document for Incomplete Vehicle" provided with each chassis.

A = Incomplete vehicle; when completed will conform providing no alterations have been made affecting items covered by FMVSS regulations and "Document for Incomplete Vehicle."

B = Incomplete vehicle; when completed by the final manufacturer will conform providing it is completed in compliance with FMVSS regulations and "Document for Incomplete Vehicle."

+ = Meets Canadian Motor Vehicle Safety Standards bearing same FMVSS number.

– = Canadian MVSS only.

4 = Not applicable to truck or bus.

5 = Not applicable to trucks with a GVWR greater than 10,000 lbs.

Compliance of this vehicle with EPA and California Certification Requirements will be maintained providing no alterations are made to the components or systems identified below:

Air Inlet System
Diesel Fuel Injections Controls
Engine Assembly with all Components of Exhaust Emission Control System
Exhaust System
Fuel System
Turbocharger and Associated Controls

NOTE: Above list is a guide. For further detailed information/clarification of the above components or systems, please refer to the "Document of Incomplete Vehicle" provided with each chassis.

WEIGHT RESTRICTIONS

Regulations and Requirements

The Gross Vehicle Weight Rating (GVWR) and the Gross Axle Weight Rating (GAWR) of each Incomplete Vehicle are specified on the cover of its Incomplete Vehicle Document in conformance to the requirements of Part 568.4 of the Federal Motor Vehicle Safety Regulations. The final stage manufacturer is responsible under Part 567.5 to place the GVWR and the GAWR of each axle on the Final Vehicle Certification Label. The regulation states that the appropriate rating “shall not be less than the sum of the unloaded vehicle weight, rated cargo load, and 150 pounds times the vehicle’s designated seating capacity.”

Unloaded vehicle weight means the weight of a vehicle with maximum capacity of all fluids necessary for operation of the vehicle, but without cargo or occupants.

During completion of this vehicle, GVWR and GAWR may be affected in various ways, including but not limited to the following:

1. The installation of a body or equipment that exceeds the rated capacities of the Incomplete Vehicle.
2. The addition of designated seating positions which exceeds the rated capacities of this Incomplete Vehicle.
3. Alterations or substitution of any components such as axles, springs, tires, wheels, frame, steering and brake systems that may affect the rated capacities of this Incomplete Vehicle.

Use the following chart to assure compliance with the regulations. Chassis curb weight and GVW rating is located on Page 2 in each vehicle section. Always verify the results by weighing the completed vehicle on a certified scale.

Curb Weight of Chassis lbs.		________ (From required vehicle section)
PLUS weight of added body components, accessories or other permanently attached components.	+	________ (Body, liftgate, reefer, etc.)
PLUS total weight of passengers, air conditioning and all load or cargo.	+	________ (Driver, passengers, accessories and load)
EQUALS Gross Vehicle Weight lbs. (GVW) of completed vehicle..	=	________ (Should equal GVWR from required vehicle section)

Gross Axle Weight Rating

The Gross Vehicle Weight is further restricted by the Gross Axle Weight Rating (GAWR). The maximum GAWR for both front and rear axles is listed in each Vehicle Section. Weight distribution calculations must be performed to ensure GAWR is not exceeded. Always verify the results by weighing the completed vehicle on a certified scale.

NOTE: Although the Front Gross Axle Weight Rating (FGAWR) plus the Rear Gross Axle Weight Rating (RGAWR) may exceed the Gross Vehicle Weight Rating (GAWR), the total GVW may not exceed the respective maximum GVWR.

The variation in the GAWR’s allow the second stage manufacturer some flexibility in the design of the weight distribution of the attached unit

Weighing the Vehicle

Front and rear GAWR’s and total GVWR should be verified by weighing a completed loaded vehicle. Weigh the front and rear of the vehicle separately and combine the weights for the total GVWR. All three weights must be less than the respective maximum shown in the vehicle sections.

Tire Inflation

Tire inflation must be compatible with GAWR and GVWR as specified on the cover of the Incomplete Vehicle Document for each vehicle.

Center of Gravity

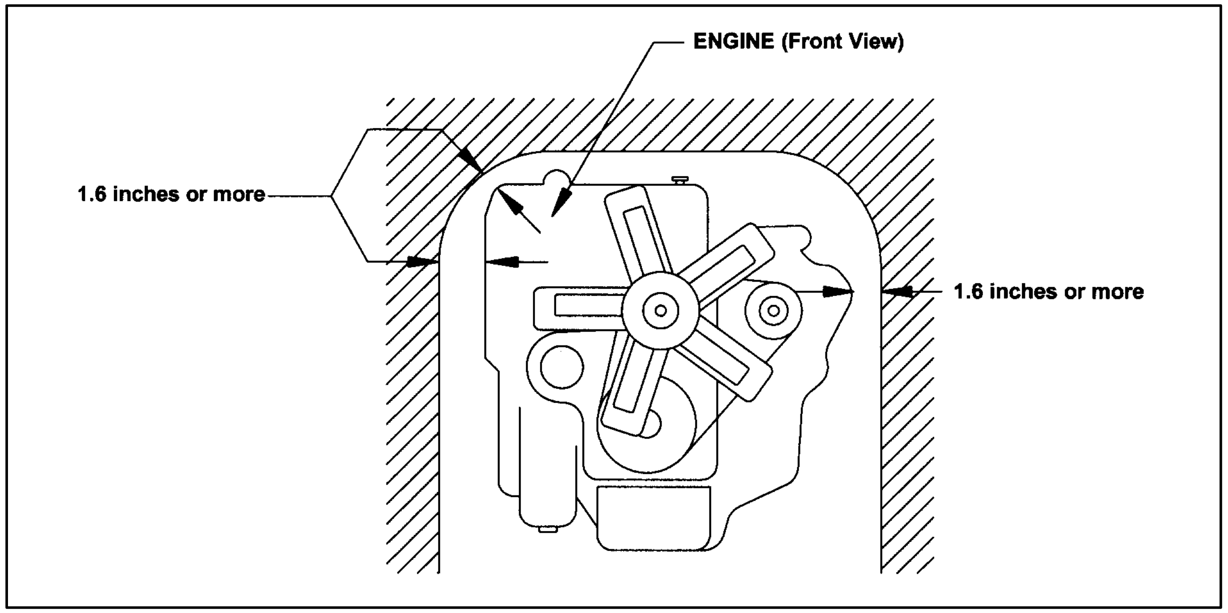
The design of the truck body should be such that the center of gravity of the added load does not exceed the guidelines as listed in each Vehicle Section. If the body is mounted in such a way that the center of gravity height exceeds the maximum height of the center of gravity designated for each model, the directional stability at braking and roll stability at cornering will be adversely affected. A vertical and/or horizontal center of gravity calculation must be performed if a question in stability arises to ensure the designed maximum height of the center of gravity is not violated.

INSTALLATION OF BODY AND SPECIAL EQUIPMENT

Clearance Around Engine, Driveline and Others

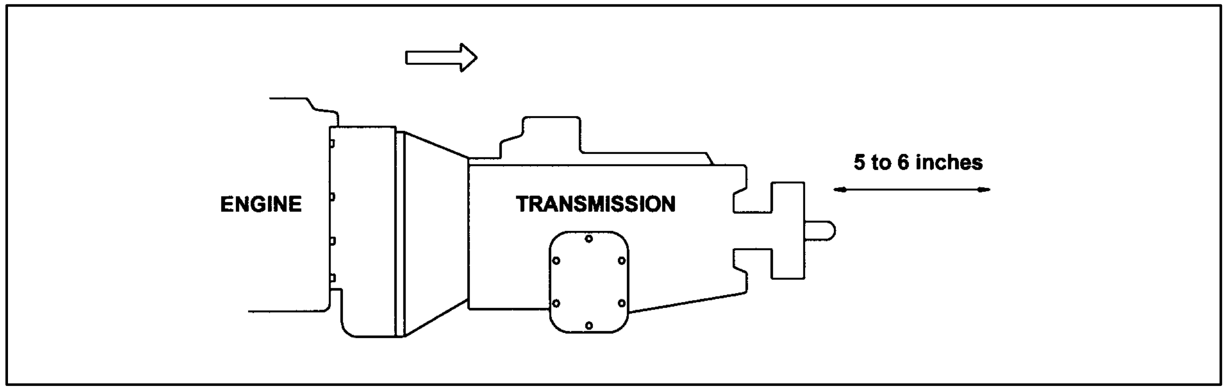
Engine

At least 1.6 in. clearance should be maintained around the engine. No obstacles should be added in front of the radiator or intercooler.

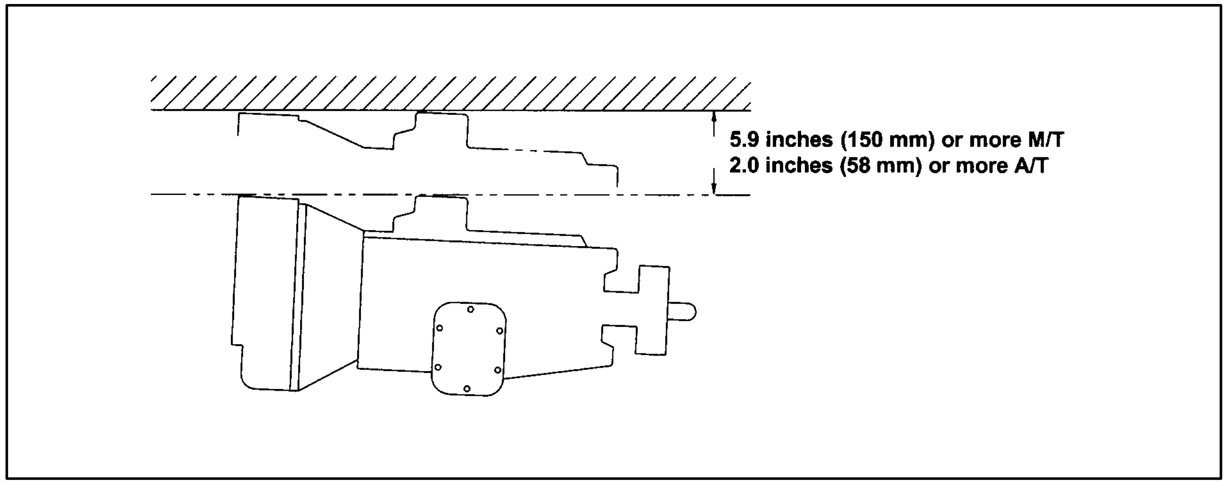


Transmission

The transmission is removed from the rear. Enough clearance must be provided to allow rearward movement of the transmission assembly. Clearance should be sufficient to allow 5 to 6 inches unrestricted movement of the transmission assembly. In addition, provide at least 2 inches clearance around the control lever on the side of the transmission to allow free movement without any binding.

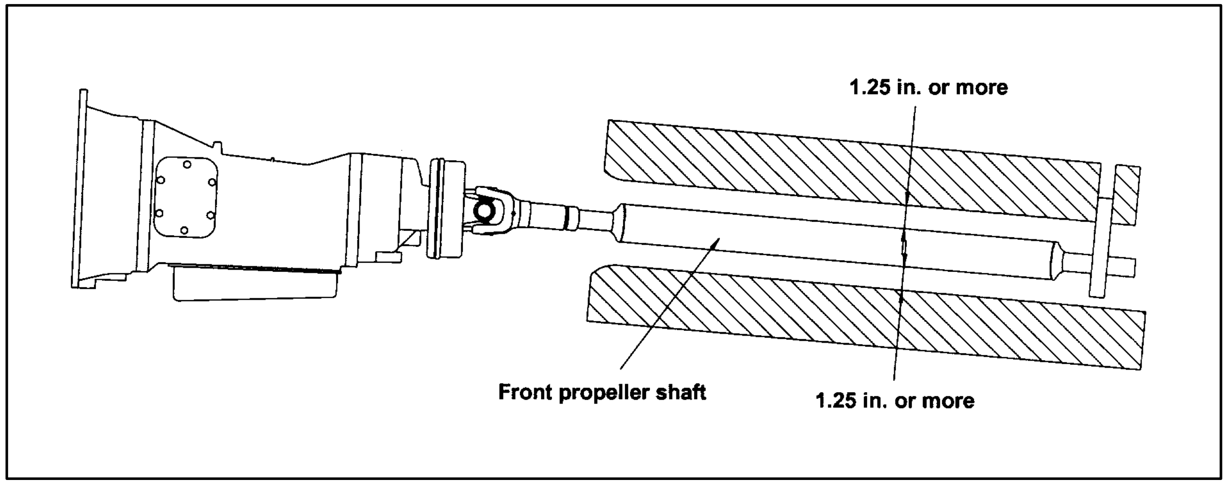


At least 6 inches clearance should be maintained above the transmission to allow easy removal of the upper cover for manual transmissions. At least 2 inches clearance should be maintained above the automatic transmission to allow for transmission removal.



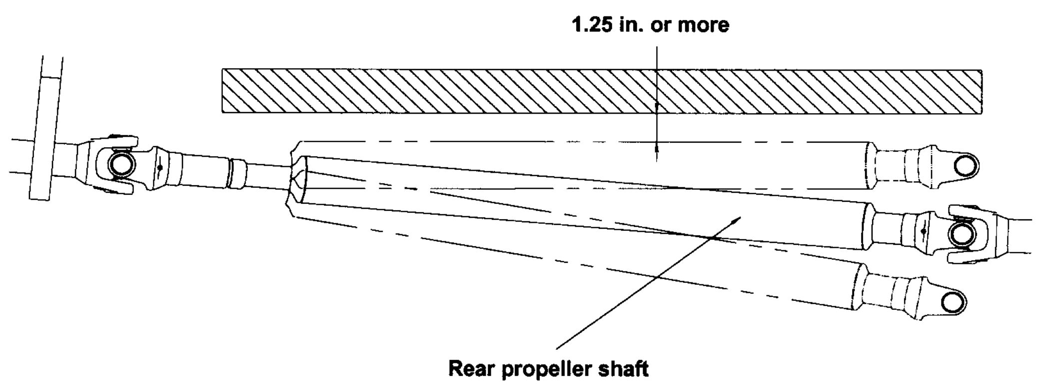
Front and Center Propeller shafts

At least 1.25 inch clearance should be maintained around front and center propeller shafts.



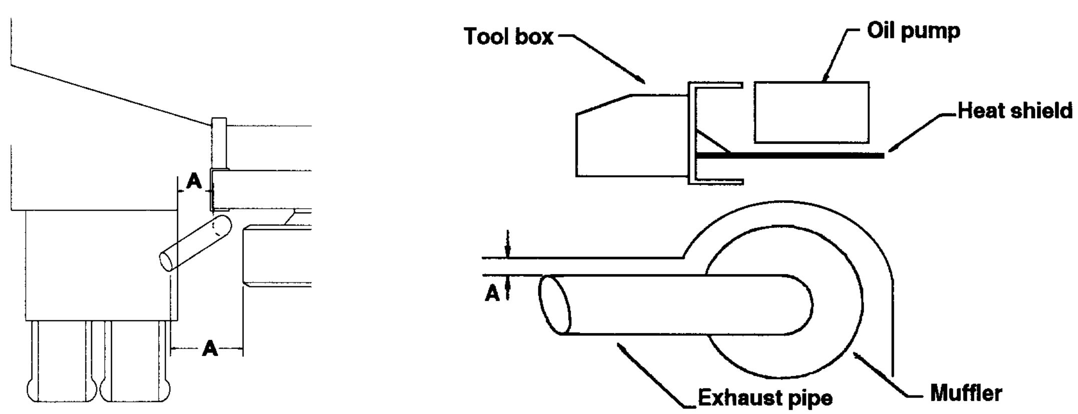
Rear Propeller Shaft

With the rear springs at maximum deflection, at least 1.25 inch clearance should be provided over the rear propeller shaft.



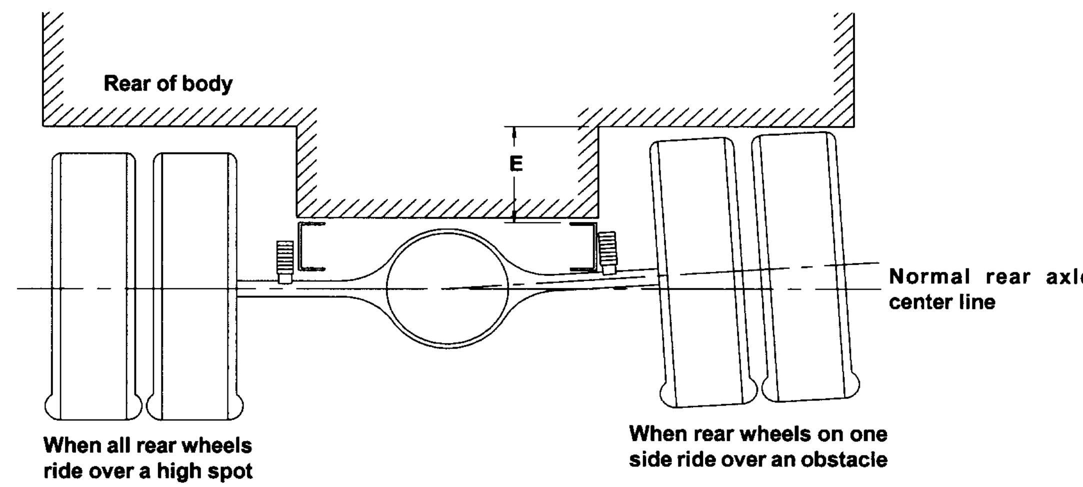
Exhaust System Clearance

If flammable materials such as wood are used in the body, provide at least 3.9 inches clearance between the body and any parts of the exhaust pipe, muffler and catalytic converter. If it is impossible to maintain this minimum clearance, use a heat shield. Also use a heat shield if an oil pump or line is located above the exhaust pipe, muffler or catalytic converter.



Rear Wheel and Axle Clearance

The design and installation of the body should allow sufficient clearance for full vertical movement of the rear wheels and axle when the vehicle travels over rough or unlevel surfaces.



Recommended clearance (Dimension E) is given in each model section. Oversize tire requires correspondingly greater clearance.

Other Clearances

Transmission control cable may be broken if it is bent by or interferes with the body and its fixtures. To prevent this, 1 inch minimum clearance should be provided. When cable is detached for body mounting, be sure not to bend the cable.

Accessibility to the grease nipple on the rear spring bracket/shackle should be provided so that serviceability with a grease gun is not hampered.

Parts	Minimum Clearance	Location
Brake Hose	6.7 in. 1.6 in.	Axle Side Frame Side
Parking Brake Cable	1.2 in.	—
Fuel Hose	1.6 in.	—
Shock Absorber	2.4 in. 1.2 in.	Axle Side Frame Side

Body Installation

To maintain the performance of the truck chassis, either a side member or subframe should always be used for body mounting.

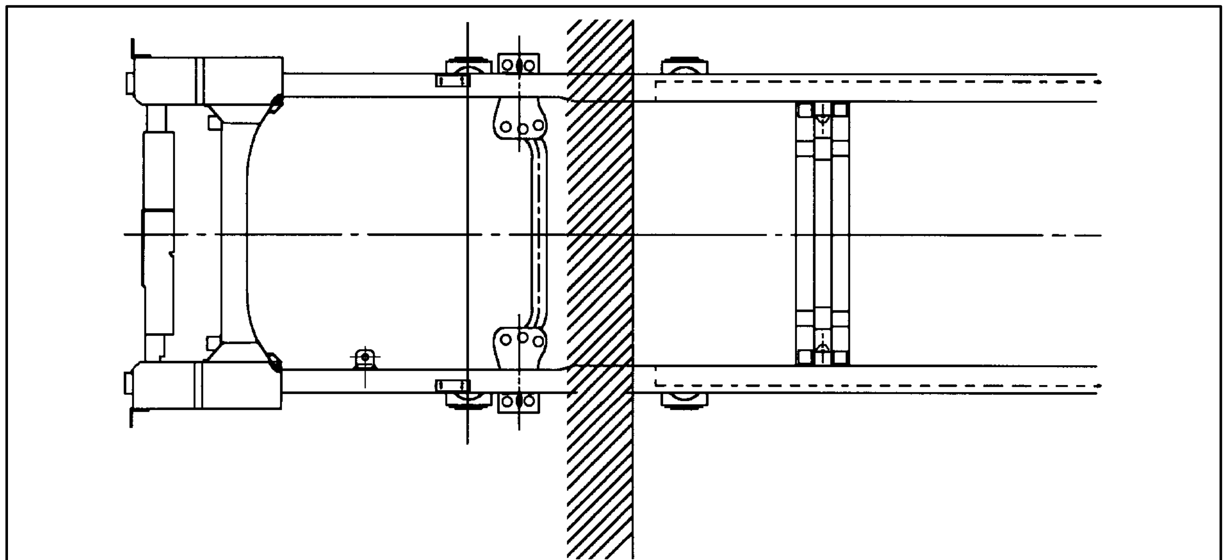
Body mounting with low rigidity will often adversely affect riding comfort.

Installation of Special Equipment on the Chassis

When installing special equipment on the chassis, extra consideration must be given to the weight and construction of the equipment to assure proper distribution of the load. Localization of the load should be prevented. All special equipment should be properly secured into position. We recommend the use of subframe members when installing special equipment.

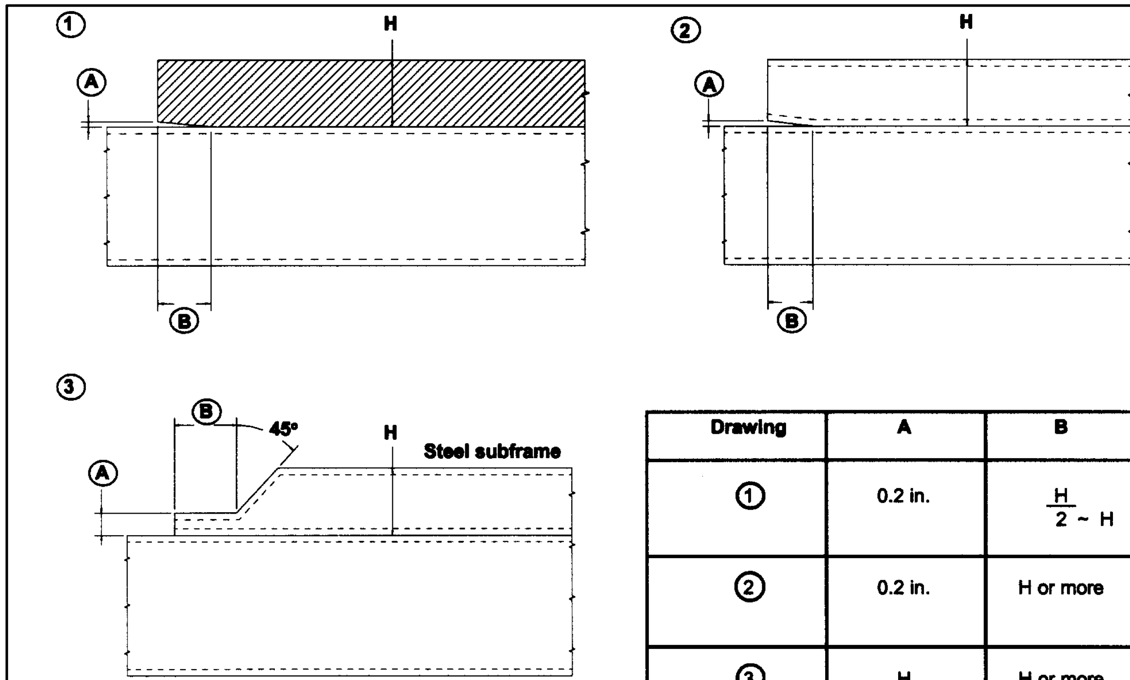
Subframe Design and Mounting

The subframe assembly should be mounted as close to the cab as possible. It should be contoured to match the shape and dimensions of the chassis frame as closely as possible.



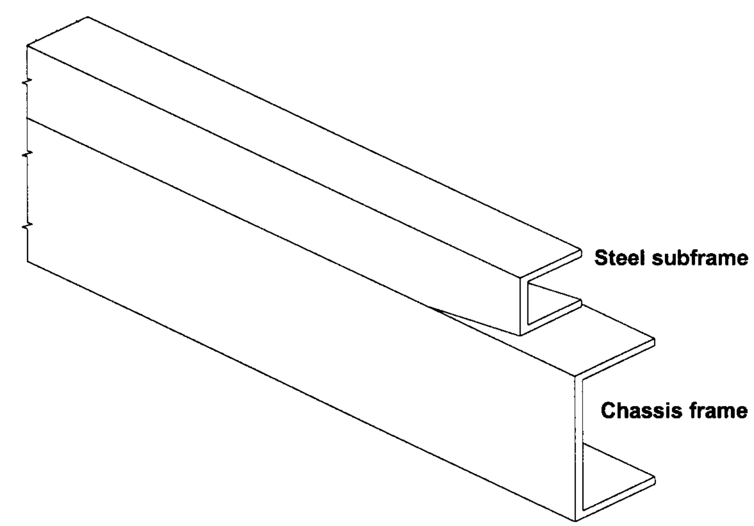
Contouring of Subframe

Contouring of the front end of the subframe members as shown in the three illustrations below will prevent stresses from being concentrated on certain areas of the chassis frame.



Drawing	A	B
①	0.2 in.	$\frac{H}{2}$ ~ H
②	0.2 in.	H or more
③	$\frac{H}{3}$	H or more

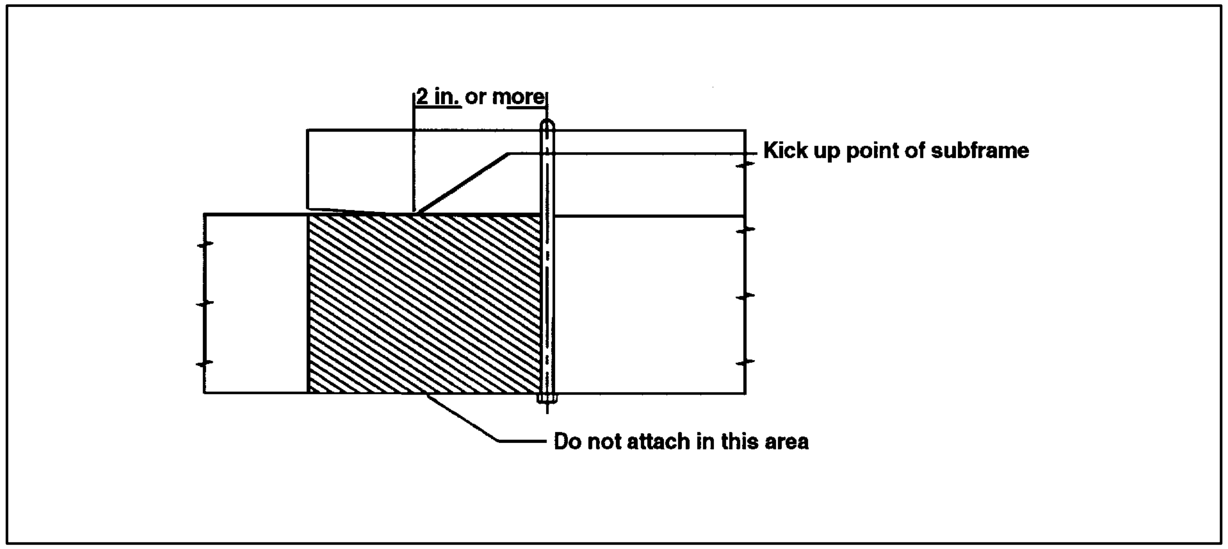
When using a steel subframe, do not close the end of the subframe.



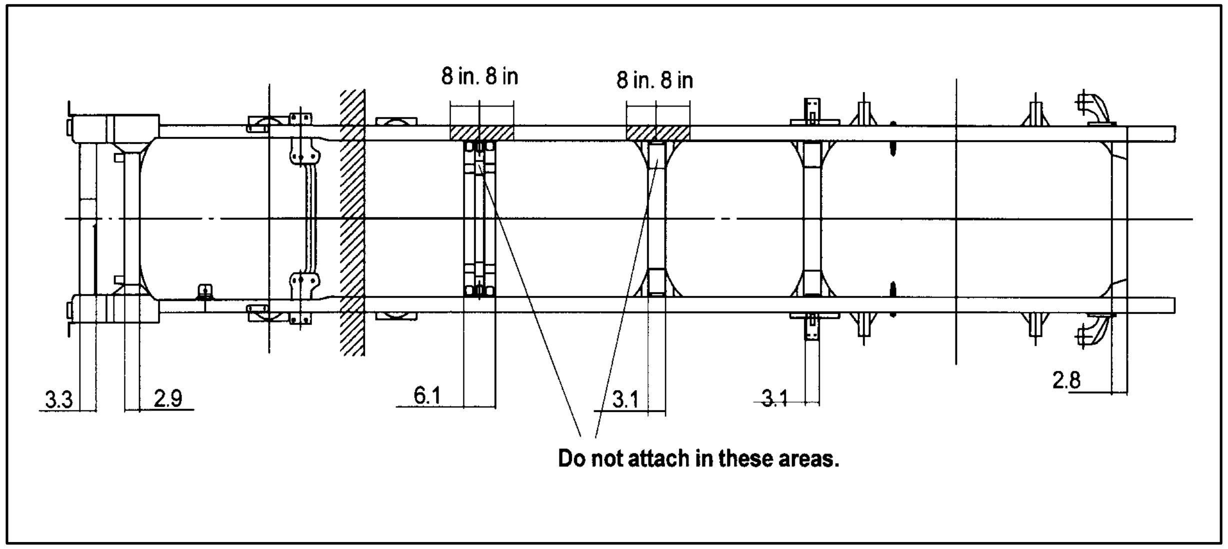
Prohibited Attachment Areas

Do not attach the supreme with a bolt on bracket to the chassis frame at the points indicated by shading in the following illustrations.

1. At the front end of the supreme. The attaching bolt or bracket must be at least 2 inches behind the kick up point of the subframe.

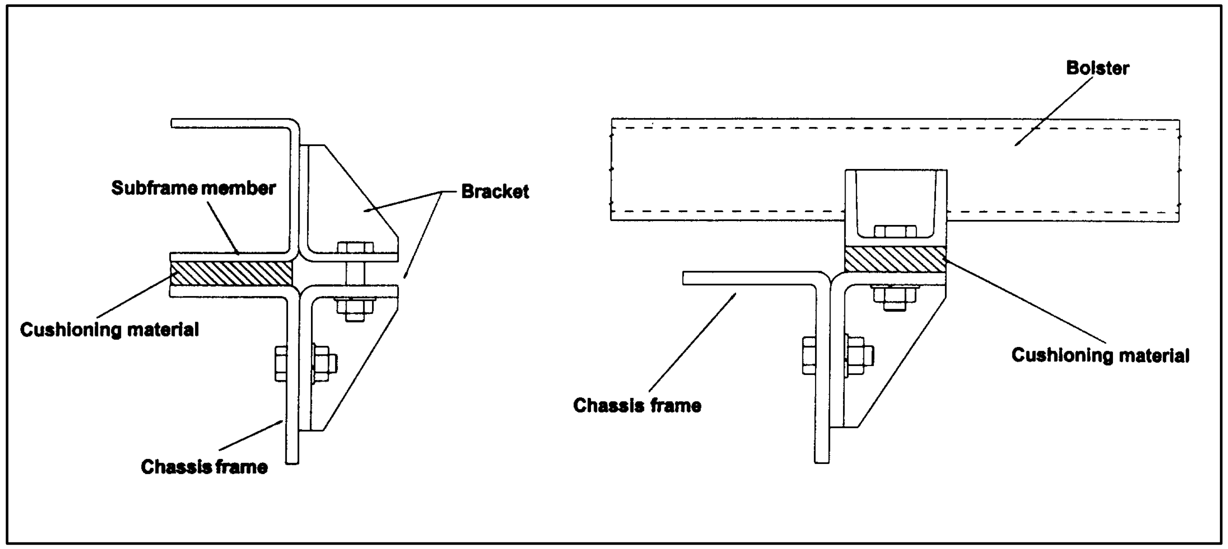


2. Within 8 inches of bends in the chassis frame or the attachment points of any cross members.



Subframe Mounting Bracket Installation

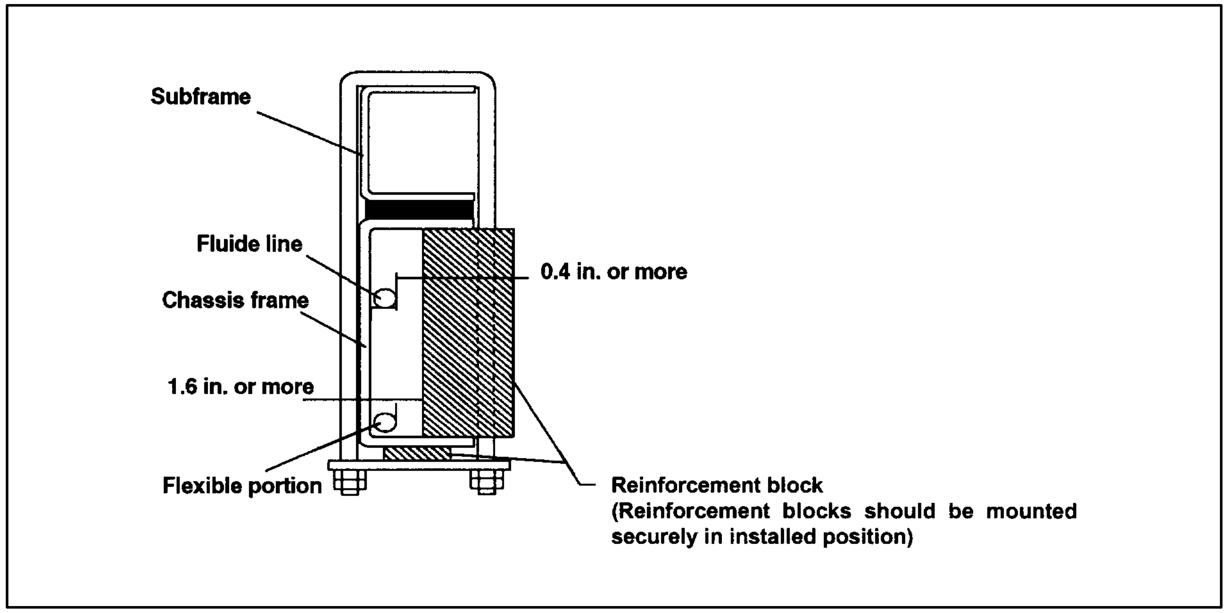
Mounting brackets should be clamped to the chassis frame using bolts. For proper positions in which to install the bolts, refer to the preceding section and the section "Modifications to the Chassis Frame."



Subframe Mounting U-bolt Installation

When U-bolts are used to retain the subframe, reinforcement blocks must be installed in the frame members. This will prevent distortion of the frame flange as they are tightened. The drawing indicates the correct placement of reinforcement blocks. If you use wood blocks, be sure that there is sufficient clearance between them and any parts of the exhaust system.

If any fluid lines or electric cables are located near the reinforcement blocks, you must provide at least 0.4 inch clearance between rigid or stationary portions, and at least 1.6 inch between moveable or flexible portions of the lines.



For the installation positions of the U-bolts, refer to "Prohibited Attachment Areas."

Modification of the Chassis Frame

Modifications of the chassis frame should be held to an absolute minimum. Modification work should be performed according to the instructions in the following paragraphs.

When modification is complete, chassis frame members should be carefully inspected to eliminate the possibility of any safety-related defects.

Working on Chassis Frame

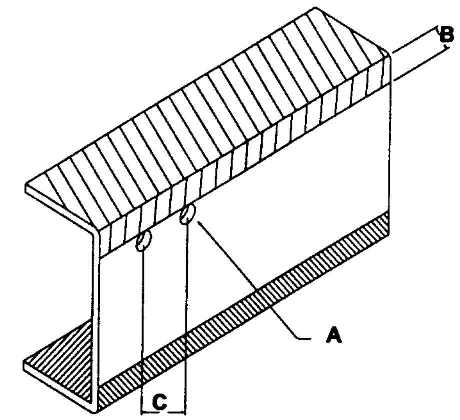
The chassis frame is designed and built with consideration for proper load distribution. Sufficient physical strength is provided when the load is evenly distributed. Installation of special equipment on the chassis frame can cause variations in load distribution. If even distribution of load is not kept in mind when the equipment is installed, localization of stresses on specific areas of the frame could cause cracking of the chassis frame members or other problems, even if the total weight of the equipment is within the design limit.

The chassis frame is designed as an integral unit. Therefore, ***we do not recommend cutting the chassis frame under any circumstances.***

Drilling and Welding

NOTE: VEHICLES EQUIPPED WITH ELECTRONIC OR HYDRA-MATIC TRANSMISSIONS, Any electric arc welding performed upon the vehicle must be done with the negative battery cable disconnected.

1. Do not drill or weld in the shaded portions of the chassis frame members. Do not weld within 0.8 inch from the edges of any existing holes.
2. Hold the length of any welding beads within 1.2-2.0 inch. Allow at least 1.6 inch between adjacent welding beads.



Dimensions: A - not more than 0.51 in. in diameter
B - must be more than 0.8 in.
C - must be more than 1.0 in.

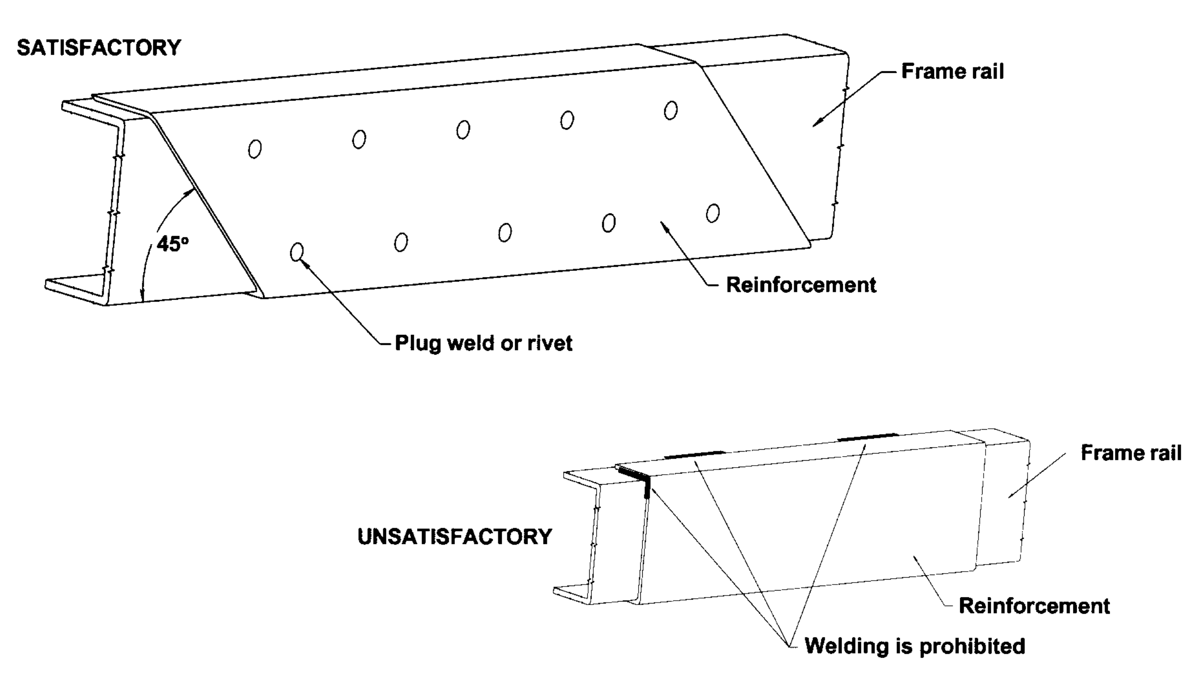
3. All holes must be drilled. Do not use a torch to make any holes.
4. All riveting must be done with cold rivets. Do not use hot rivets.
5. The flange of the chassis frame must not be cut under any circumstances.
6. The subframe must be attached to the chassis frame with bolts. Do not weld.

Reinforcement of Chassis Frame

Reinforcements must be installed to prevent the considerable variation in the section modulus. They must be welded so as to avoid localized stresses.

The frame of the W3500, W4500 and W5500 is made of SAPH440 mild steel.

The drawing below illustrates correct and incorrect methods of frame reinforcement.



Welding

1. Keep reinforcement plates and chassis frame free from moisture and water.
2. Avoid cooling with water after welding.
3. Use a suitable means to protect pipes, wires, rubber parts, leaf springs, etc. against heat and affect of sputtering.
4. Remove fuel tank assembly when welding portions near the fuel tank.
5. Remove coat of paint completely when welding painted areas.

Fluid Lines

Do not disturb the layout of any brake lines or fuel lines unless absolutely necessary. When modification is needed, follow the instructions below carefully to ensure safety. Brake fluid lines must not be cut and spliced under any circumstances. We do not recommend the cutting or splicing of any fuel lines, but if it is absolutely necessary, be sure that the correct fitting and tools are used to form the joint, and then pressure test the joint. Steel lines are metric sizes.

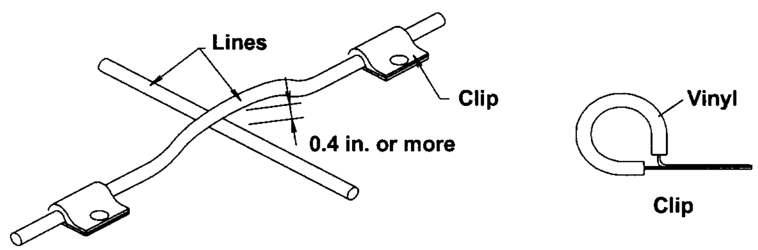
Preparation of Additional Lines

1. Where possible, use only genuine GM/Isuzu lines as supplied by authorized GM/Isuzu dealers.
2. Use the correct metric flaring and bending tools to form the lines.
3. Avoid repeated bending. Do not use heat for flaring and bending the lines. Before and after forming the new lines, examine them carefully for scratches, distortion, dents and the presence of any foreign matter.

Installation of Additional Lines

Install new lines away from adjacent parts and away from any sources of heat.

1. A minimum clearance of 0.4 inch must be maintained between lines. Where necessary, clip the lines into position in order to maintain this minimum clearance.
2. Minimize any crossing between lines. If a crossing is unavoidable, use the following procedure:
   a. At least 0.4 inch clearance should be maintained between lines at the crossing point.
   b. If the 0.4 inch clearance cannot be maintained, or if the lines are subject to vibration, clip them securely.
3. Plan the bends and clipping points of the lines to minimize vibration and the resulting fatigue.
4. Use rust-proofed clips and apply vinyl coating to the portions of the lines to be clipped.
5. Install new lines in positions where they are protected against water, dirt, grit, sand, rocks and other foreign matter that can come from above or below, or can be flung up by the wheels.



Electrical Wiring and Harnessing

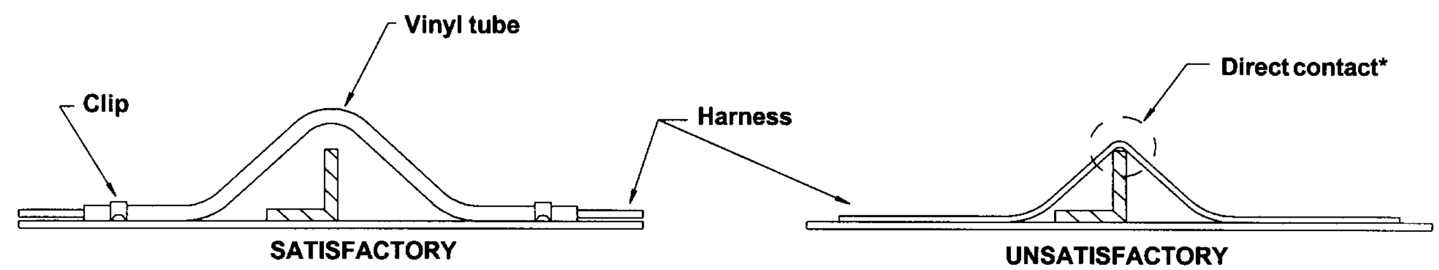
To increase the reliability of the wiring, all frame harnesses are covered with corrugated vinyl tubing. The following instructions apply to extending or modifying these harness. See the Electrical Section for information on commonly used circuits in the W3500, W4500 and W5500 sections.

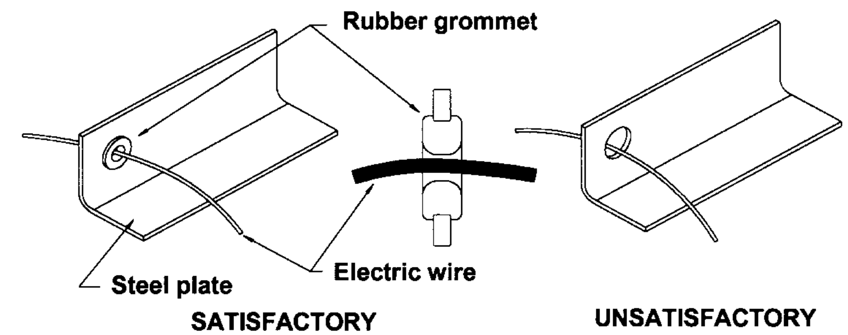
Wiring

1. Most wiring connections on GM/Isuzu vehicles are made with terminals. We recommend the use of terminals when splicing cables and wires.
2. When splicing, use new wire of the same gauge, and do not make splices inside the corrugated tubing.
3. When making connections to the end of the harness, make sure the connections are electrically perfect. Use insulating tape as needed to prevent the entry of water, which results in short circuits and/or corrosion.
4. When making new circuits, or modifying circuits already installed, make the cables only just taut enough to remove any slack. Use clips or grommets where required to protect cables from heat or sharp edges. When cables must run near the exhaust system, see the instructions in the “Exhaust System” section.
5. Always use rustproof clips, and apply vinyl coating to that portion of the clips in direct contact with the harnesses. No scotch clips or connectors.
6. To minimize the vibration of the harness, clipping points should be set up according to the table.

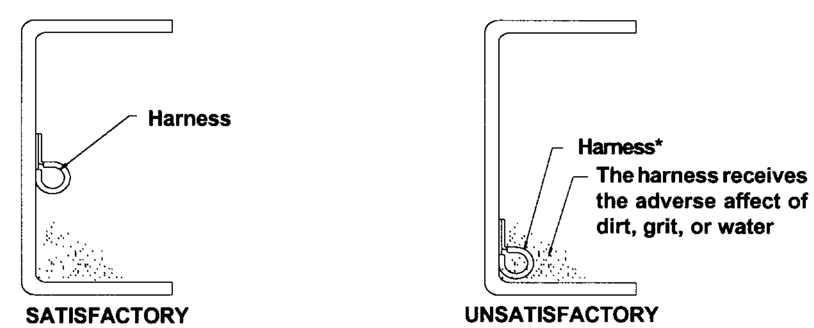
Harness Diameter	Clip Distance
less than 0.2 in.	less than 11.8 in.
0.2 in. ~ 0.4 in.	approx. 15.7 in.
0.4 in. ~ 0.8 in.	approx. 19.7 in.

7. When changing the length of the battery cable, do not cut or splice the existing cable. Make up a new cable of the correct length and wire gauge for the load and distance, without splices.
8. When using connectors, use a socket (female) connector on the electrical source side and a plug (male) connector on the electrical load side to lower the possibility of a short circuit when disconnected.
9. When connecting cables to moving or vibrating parts such as the engine or transmission, be sure to maintain sufficient slack in the wiring to absorb the vibration. Follow the example of existing cables connected by GM/Isuzu. Keep flexible cables clear of other parts.
10. Do not use vinyl tape in the engine compartment. The heat will ten to make it peel off. Use plated steel clips coated with rubber or vinyl.



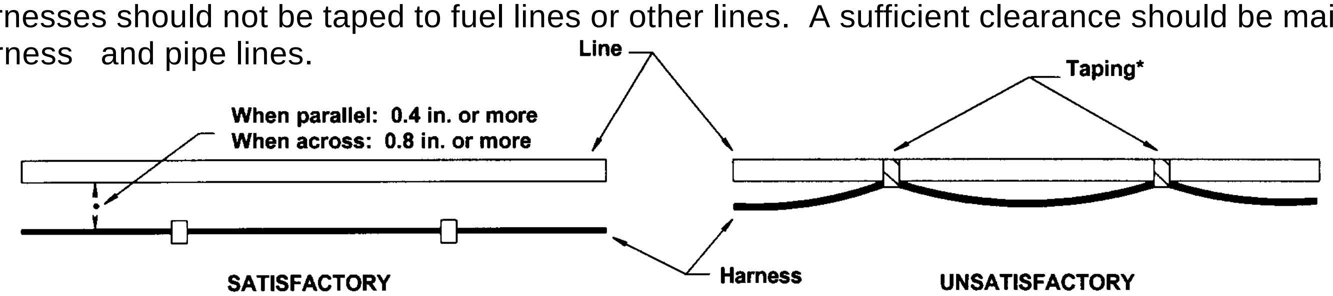


* Cables should not be in contact with sharp edges or pierced holes.



* Harnesses should not be installed on inside lower face of the chassis frame.

* Harnesses should not be taped to fuel lines or other lines. A sufficient clearance should be maintained between harness and pipe lines.



Wire Color Code

The electrical circuits of GM/Isuzu vehicles NPR, NPR GAS and FRR are connected with low-voltage stranded wire for automotive applications. The color coding standards are as follows for W3500, W4500 and W5500:

(1)	Black	B	Starter circuits and grounds
(2)	White	W	Generator (alternator) circuit
(3)	Red	R	Lighting circuit
(4)	Green	G	Signal circuit
(5)	Yellow	Y	Instrument circuit
(6)	Brown	Br	Accessory circuit
(7)	Light Green	Lg	Other circuit
(8)	Blue	L	Windshield wiper motor circuit

Maximum Current Allowable in Low Voltage Wiring

Harness Design Diameter (mm)	AWG Equivalent	No. of Wires/ Wire Diameter (mm)	Cross Sectional Area (mm^2)	Maximum Allowable Current (Amps)
100	00	217/0.80	109.1	363
85	0	169/0.80	84.96	305
60	1	127/0.80	63.84	248
50	1	108/0.80	54.29	223
40	1	85/0.80	42.73	191
30	2	70/0.80	35.19	171
20	4	41/0.80	20.61	123
15	6	84/0.45	13.36	93
8	8	50/0.45	7.952	68
5	8	65/0.32	5.228	51
3	12	41/0.32	3.297	39
2	14	26/0.32	2.091	29
1.25	16	16/0.32	1.287	21
0.85	18	11/0.32	0.8846	17
0.5	20	7/0.32	0.5629	13

Reference: The values given in the “Maximum Allowable Current” column are based on the ambient temperature condition of 104° F with temperature increase of 104° F.

Exhaust System

Modification of the exhaust system should be avoided. If modifications are absolutely necessary, the following points should be maintained.

1. Maintain the clearance specified in the “Exhaust System” table between all parts of the exhaust system and any fuel lines, brake lines, brake hoses, electrical cables, etc. The exhaust outlet should not point toward any of these parts.

	Clearance
Brake Lines	2.4 in. or more. (If the combined section of a group of parallel brake lines is more than 7.8 in., a clearance of 7 in. or more should be provided.)
Flexible Brake Hoses	3.9 in. or more. (The temperature of flexible brake hoses should not exceed 158° F. If the highest temperature is not measurable, a clearance of more than 15.7 in. should be maintained between the hoses and the exhaust system.
Wiring Harnesses and Cables	3.9 in. or more.
Steel Fuel Lines	3.1 in. or more.
Rubber or Vinyl Fuel Hoses	5.9 in. or more.

2. If a tool box is installed, it should preferably be made from steel. If a wooden tool box is installed, at least 7.8 inches clearance should maintained between the tool box and any parts of the exhaust system.
3. If the exhaust system is modified, it is the responsibility of those making the modification to ensure that the noise level meets appropriate standards.

Fuel System

Relocation of the fuel tank, or installation of additional fuel tanks is not recommended. If modifications to the fuel system are unavoidable, follow these recommendations:

1. Maintain adequate clearance between the fuel tank and any other device or structure.
2. Do not connect an additional fuel hose.

Rear Comb. Lamp/License Plate Lamp Mounting Bracket

Brackets installed are temporary. Please do not use these brackets for body installation.

Serviceability

No matter what other modifications or changes are made, access to components requiring daily preventive maintenance or other routine service must not be obstructed. This includes:

1. Inspection, filling and draining of engine oil and cooling water.
2. Inspection, filling and draining of transmission fluid.
3. Adjustment, removal and installation of the fan belts.
4. Inspection, filling and removal of the battery and battery cover.
5. Inspection and filling of brake fluid.
6. Inspection and bleeding of the brake system and servo unit.
7. Maintenance of clearance for tightening of check bolt on brake safety cylinder.
8. Operation of the spare tire carrier, including mounting and dismounting of the spare tire.
9. Adjustment, removal and installation of distributor and/or cover.

Wheelbase Alteration

With certain applications, it may become necessary to alter the wheelbase of the chassis. The next two sections provide the suggested guidelines for accomplishing either shortening or lengthening of the wheelbase.

Shortening/Lengthening the Wheelbase without Altering the Frame

Since the frame is an integral part of the chassis, it is recommended that the frame not be cut if it is possible to avoid it. When shortening/lengthening the wheelbase on some models, it is possible to do so without cutting the frame. This is possible on models which have a straight frame rail. If the chassis does not have a straight frame rail, it may still be necessary to cut the frame. For instructions on shortening/lengthening these chassis, refer to the ALTERING THE WHEELBASE BY ALTERING THE FRAME section of this book. Otherwise, the wheelbase may be shortened/lengthened by removing the rear suspension, drilling new suspension mounting holes at the appropriate spot in the frame, and sliding the rear suspension, suspension liner, and suspension crossmembers forward or aft. The suspension and suspension crossmembers' rivet holes left in the frame rail flange must be filled with GRADE 8 bolts and hardened steel washers at ***both*** the bolt head and nut, HUC bolts or GRADE 8 flanged bolts and hardened steel washers at the nut. When shortening/lengthening the wheelbase in this manner, the following guidelines must be adhered to:

1. All frame drilling must comply with the DRILLING AND WELDING section of this book.
2. All rivet holes left in the frame rail flange from the suspension and suspension crossmembers must be either filled with GRADE 8 bolts and hardened steel washers at ***both*** the bolt head and nut, HUC bolts or GRADE 8 flanged bolts and hardened steel washers at the nut.
3. The components required to be slid forward or aft are the suspension and suspension hangers, suspension crossmembers and suspension frame liner.

Altering the Wheelbase by Altering the Frame

Even on a straight frame rail, it may be desirable to cut the frame and lengthen or shorten the wheelbase rather than simply sliding the rear suspension back or forward. The following section offers some guidelines and suggestions for cutting and lengthening or shortening the frame.

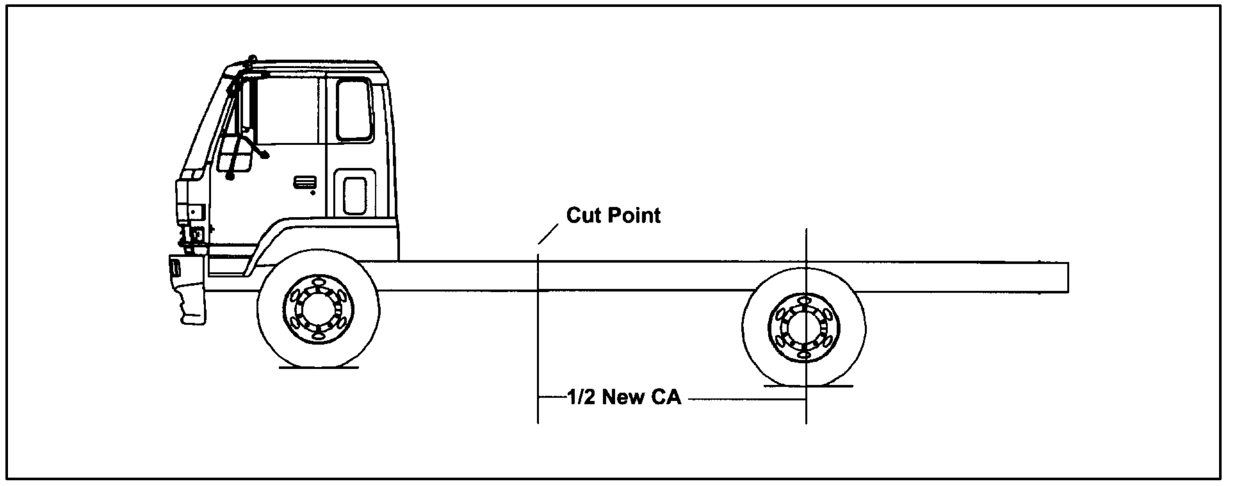
Glossary of Terms–Chassis Wheelbase Alteration

CA – Length from back-of-cab to rear axle center line in inches.

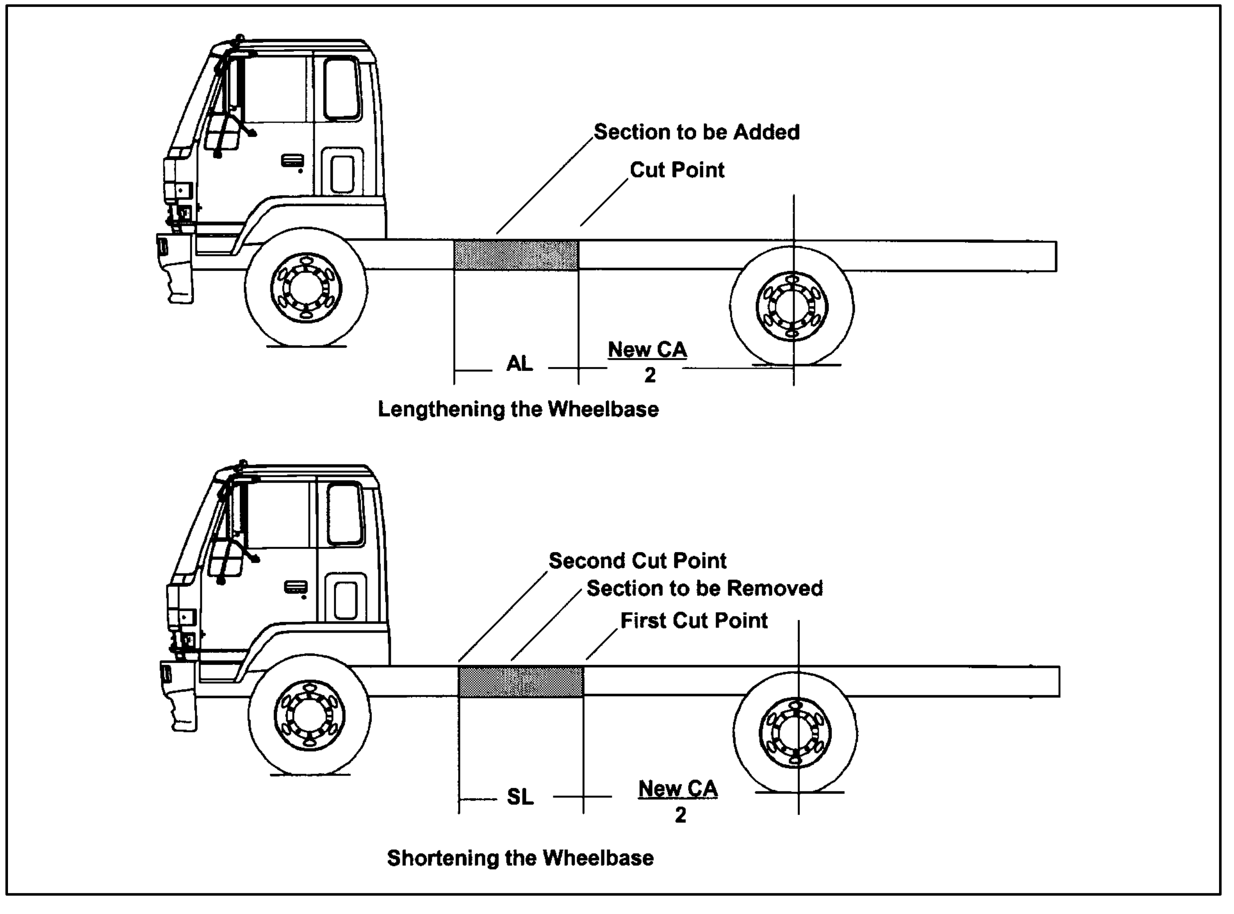
AL – Added length (in case of a lengthened wheelbase.) Difference between WB (new) and WB (old).

SL – Shortened length (in case of shortened wheelbase). Difference between WB (old) and WB (new).

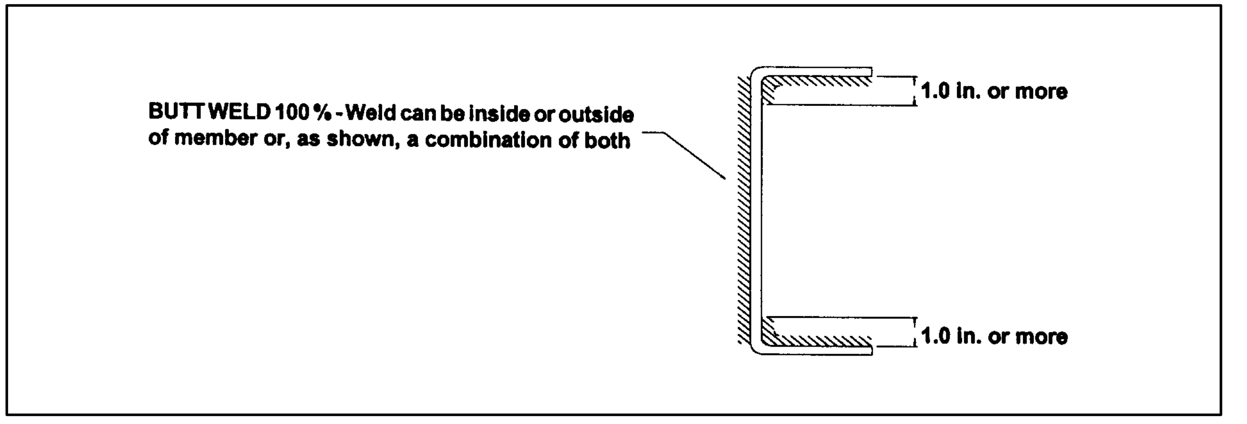
1. Determine the added length (AL) or shortened length (SL) required to lengthen or shorten chassis. (For added wheelbase: New CA = CA + AL; For shortened wheelbase: New CA = CA – SL)
2. Obtain the material to be used as the insert for the lengthened wheelbase in the correct length (AL). The insert must have the same cross sectional dimensions and yield strength as the original frame rail.
3. Divide the new CA by two (2). Measure (new CA)/2 from the center of the rear axle forward and mark this point on the chassis frame.



4. Cut the chassis frame at this point. If the wheelbase is to be lengthened, addition of the previously obtained insert (of length AL determined in step 1) will be made at this time. If the wheelbase is to be shortened, measure the distance (SL) forward of this cut and remove a length (SL) section from the chassis frame. Insure that an adequate area on the frame remains for the required addition of the necessary reinforcements. These are the only suggested places for cutting the frame and reinforcements but may be changed upon the advice of GM/Isuzu Application Engineering.



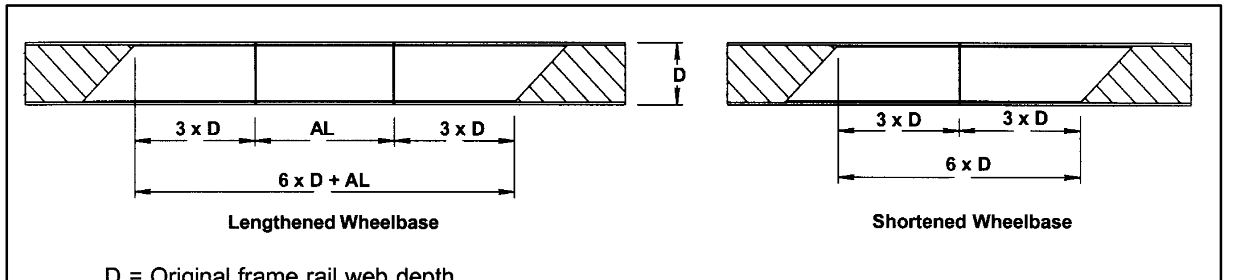
5. When welding the insert (length AL for wheelbase lengthening) to the original frame rail, a continuous butt weld must be used at the splices. When shortening the wheelbase, weld the ends of the chassis frame together with a continuous butt weld over the junction of the frame ends. Weld both the inside and outside of the frame rails using welding techniques prescribed by established welding standards (ref. SAE J1147) and in accordance with this guide. An example of this weld is shown below.



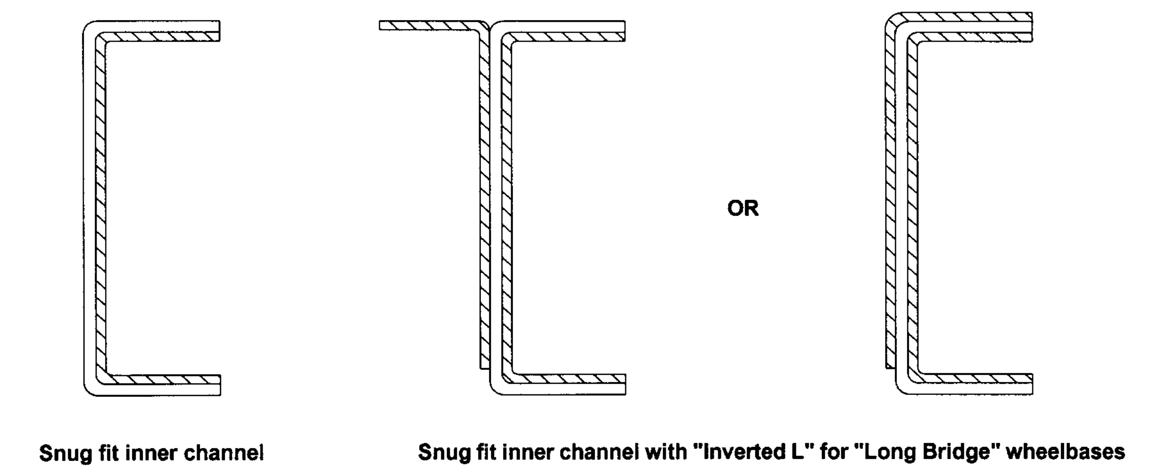
6. Determine the appropriate additional internal reinforcements which are required using this equation:

   Reinforcement Length = AL + 6 x (original frame rail web depth).

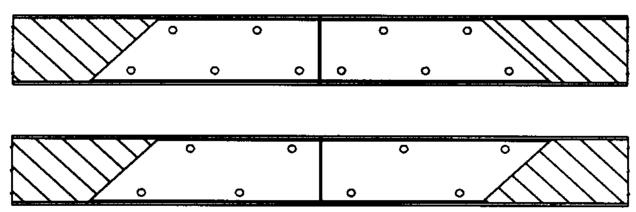
The figure below shows how this reinforcement is to be placed over the extended or shortened section of the frame rail.



The suggested cross section of this reinforcement is a snug fit inner channel. If the new wheelbase exceeds the upper limit of the optional wheelbases of this model, i.e.; a "long bridge", it may be necessary to use an "inverted L" reinforcement in addition to the snug fit channel reinforcement (see figures below). GM/Isuzu Application Engineering should be consulted for approval of such cases. It should be noted that these methods of reinforcements, and any other methods which may be used, require a 45° angled cut at both ends to avoid stress concentrations in the frame (note the figures under item 7).



7. The reinforcements must be fastened securely to ***only*** the web of the original chassis frame rail. The reinforcement must be held rigidly in place using either HUC bolts, GRADE 8 bolts and hardened steel washers at ***both*** the bolt head and nut, or GRADE 8 flanged bolts and hardened steel washers at the nut. Below are some suggested bolt patterns. It should be noted that these bolt patterns must not align the bolts vertically, i.e.: the bolt pattern must be staggered.



8. Lengthening the frame will also require extending the brake lines and electrical harness. It is recommended that the original brake lines be removed and replaced with brake lines of the same diameter as the original lines and of the appropriate length. The electrical harness must be extended in accordance with the ***Electrical Wiring and Harnessing*** requirements.

9. The propeller shafts' overall length will also need to be lengthened or shortened. If the extension is within the limits of the optional wheelbases of the respective model, the exact propeller shaft lengths and angles are given within each section of this book. If the modified wheelbase exceeds the optional wheelbases of the respective model, the following guidelines must be adhered to:

   a. Propeller Shaft Length

   The maximum propeller shaft lengths (pin to pin) for the respective models are shown in the following table.

	W3500 W4500 Diesel	W3500 W4500 GAS	W5500
Propeller Shaft Diameter (in.)	3.25	3.0	3.0
Maximum Propeller Shaft Length (in.)	50.8	50.8	50.8

   b. Propeller Shaft Angles

   The maximum propeller shaft angles, with respect to the previous shaft, are shown in the following table.

	W3500 W4500 Diesel	W3500 W4500 GAS	W5500
Maximum Propeller Shaft Angle	5.7°	5.1°	5.7°

   c. The propeller shaft angles must be designed such that the angles will cancel to avoid propeller shaft whip.

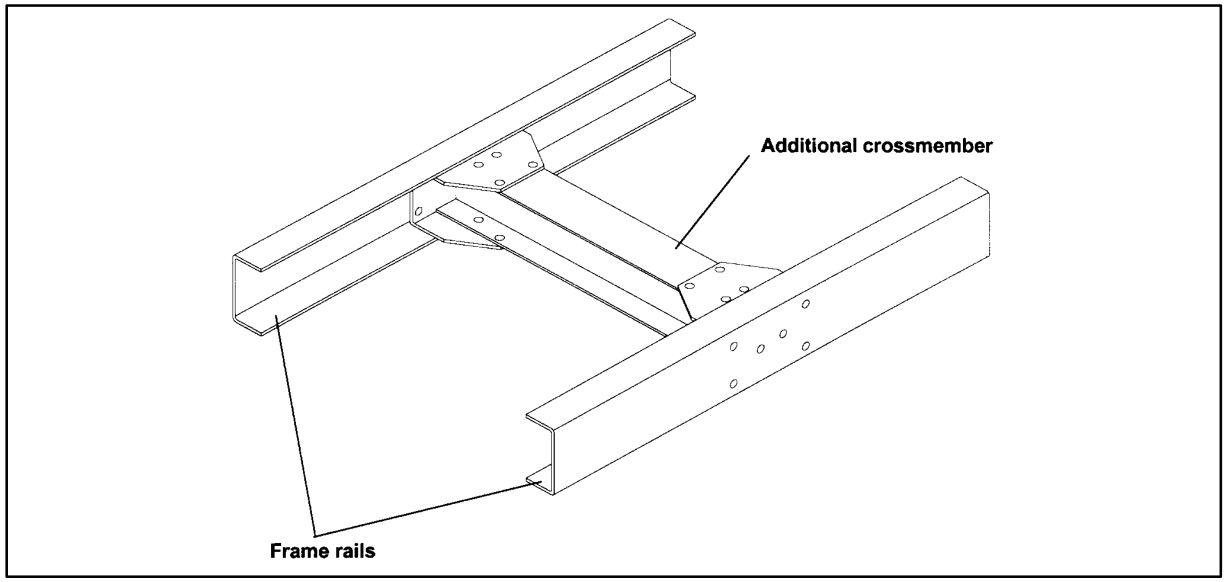
   d. The propeller shaft yokes must be assembled such that the propeller shaft yokes are "in phase." In phase means that the yokes at either end of a given propeller shaft assembly are in the same plane.

10. Extending the frame will also require relocation and/or addition of crossmembers. If the extension is within the limits of the optional wheelbases of the respective model, the exact cross member locations and dimensions are given in the respective model sections of this book. If the modified wheelbase exceeds the optional wheelbases of the respective model, the following guidelines must be adhered to:

   a. The cross member location will largely be determined by the propeller shaft lengths and where the center carrier bearing locations are for the propeller shaft assembly.

   b. A cross member must be located at the front and rear spring hangers of the rear suspension (refer to the appropriate section of this book to see where these suspension cross members are to be located).

   c. The cross member must be constructed such that it supports both the upper and lower flange on each frame rail. A cross member such as the one below may be constructed, or GM/Isuzu cross members may be obtained from your GM/Isuzu parts dealer.



d. The maximum distance between crossmembers for the respective models is given in the following table.

	W3500 W4500 Diesel	W3500 W4500 Diesel	W5500
Maximum Distance Between Cross Members (in.)	35.7	35.7	35.7

e. The drilling for any additional holes in the frame rails must comply to the ***Drilling and Welding*** section.

11. All other aspects of lengthening or shortening the wheelbase must comply with the applicable section of this Body Builders Book. For special applications and longer than recommended body lengths, GM/Isuzu Application Engineering must be consulted for approval. In the West Coast call 1-310-699-0500 extension 2385 and in the East Coast call 1-770-475-9195 extension 353.

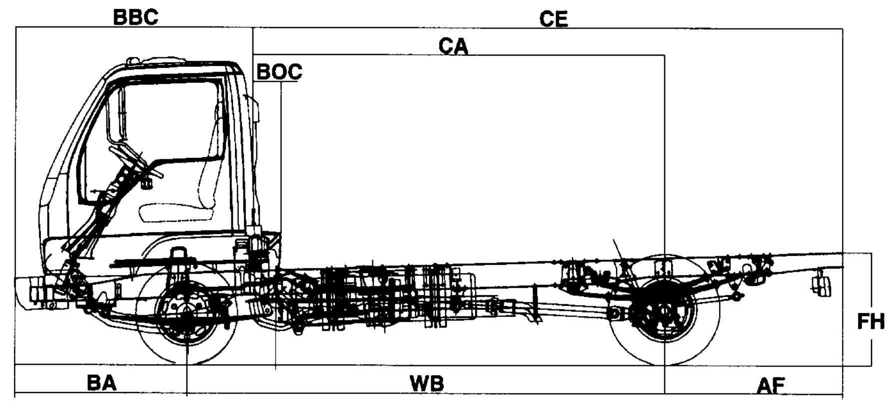
1999 MODEL YEAR BODY APPLICATION SUMMARY CHART

Model/GVWR	WB	BOC	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.	22 ft.	24 ft.	26 ft.
	109	9.25	X	X							
W3500 Gas	132.5	9.25			X						
11,050 lbs.	450	9.25				X	X				
	176	9.25						X*			
	109	9.25	X	X							
W4500 Gas	132.5	9.25			X						
14,050 lbs.	450	9.25				X	X				
	176	9.25						X*			
	109	9.25		X							
W3500 Diesel	132.5	9.25			X						
11,050 lbs.	450	9.25				X	X				
	176	9.25						X*			
	109	9.25		X							
W4500 Diesel	132.5	9.25			X						
14,500 lbs.	450	9.25				X	X				
	176	9.25						X*			
	109	9.25		X							
W5500 Diesel	132.5	9.25			X						
16,500 lbs.	450	9.25				X	X				
	176	9.25						X	X*		

*= W3500, W4500 Gas and Diesel 20 foot body requires GM/Isuzu Application Engineering Department approval

IMPORTANT: Body selection recommendations are based on water-level weight distribution and no accessories, liftgate or refrigeration units. This table is intended for reference and does not preclude the necessity for an accurate weight distribution calculation.

1999 MODEL YEAR* BODY & PAYLOAD WEIGHT DISTRIBUTION (% FRONT/% REAR)



Model	GVWR	WB	CA	CE	OAL	BOC	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.
Automatic Transmission												
W3500 Gas	11,050	109	88.4	131.5	199.5	9.25	18/82	7/93				
W4500 Gas	14,050	109	88.4	131.5	199.5	9.25	18/82	7/93				
W3500 Gas	11,050	132.5	111.9	155	223	9.25			14/86			
W4500 Gas	14,050	132.5	111.9	155	223	9.25			14/86			
W3500 Gas	11,050	150	129.4	172.5	240.5	9.25				16/84	8/92	
W4500 Gas	14,050	150	129.4	172.5	240.5	9.25				16/84	8/92	
W3500 Gas	11,050	176	155.4	198.5	266.3	9.25						15/85*
W4500 Gas	14,050	176	155.4	198.5	266.3	9.25						15/85*
Manual/Automatic Transmission												
W3500 Diesel	12,000	109	88.4	131.5	199.5	9.25		7/93				
W4500 Diesel	14,500	109	88.4	131.5	199.5	9.25		7/93				
W3500 Diesel	12,000	132.5	111.9	155	223	9.25			14/86			
W4500 Diesel	14,500	132.5	111.9	155	223	9.25			14/86			
W3500 Diesel	12,000	150	129.4	172.5	240.5	9.25				16/84	8/92	
W4500 Diesel	14,500	150	129.4	172.5	240.5	9.25				16/84	8/92	
W3500 Diesel	12,000	176	155.4	198.5	266.3	9.25						15/85*
W4500 Diesel	14,500	176	155.4	198.5	266.3	9.25						15/85*

General Information

Model	GVWR	WB	CA	CE	OAL	BOC	10 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.	22 ft.
Manual/Automatic Transmission													
W5500 Diesel	16,500	109	88.4	131.5	199.5	9.25		7/93					
W5500 Diesel	16,500	132.5	111.9	155	223	9.25			14/86				
W5500 Diesel	16,500	150	129.4	172.5	240.5	9.25				16/84	8/92		
W5500 Diesel	16,500	176	155.4	198.5	266.3	9.25						15/85	8/92**

* W3500, W4500 Gas and Diesel 20 foot body requires GM/Isuzu Application Engineering Department Approval.

** W5500 Diesel 22 foot body requires GM/Isuzu Application Department Approval.

IMPORTANT: Weight distribution percentages listed do not include added accessories, liftgate or refrigeration units. Percentages based on water-level distribution of body and payload weight which is determined by subtracting chassis wet weight (including 200 lb. driver) from GVWR. These tables are intended for reference and do not preclude the necessity for an accurate weight distribution calculation.

1999 GM/ISUZU SERIES TRUCK PRODUCT ENGINES

The following table presents Net versus Gross Horsepower and Torque ratings:

Engine Model	Application	Net Hp[1] Hp/Rpm	Net Torque[1] Lbs-ft./Rpm	Gross Hp[1] Hp/Rpm	Gross Torque[1] Lbs-ft./Rpm
GMPT 5.7L-V8	W3500, W4500 Gas	N/A	N/A	250/4200	330/2800
GM/Isuzu 4HE1-TC Manual Trans.	W3500, W4500 Diesel	137/2800	268/1300	142/2800	275/1300
GM/Isuzu 4HE1-TC Automatic Trans.	W3500, W4500, W5500	169/2700	339/2000	175/2700	347/2000
GM/Isuzu 4HE1-TC Manual Trans.	W5500 Diesel	169/2700	339/2000	175/2700	347/2000
GM/Isuzu 6HK1-TC Manual Trans./Auto. Trans.	FSR & FTR	197/2400	427/1500	200/2400	441/1500
GM/Isuzu 6HK1-TC Manual Trans.	FVR	227/2400	490/1500	230/2400	506/1500

NOTE: 1) Horsepower and Torque Ratings measured under SAE J1349 standards.

GVW/GCW Ratings

Truck Model	Transmission	GVWR (lbs.)	GCWR (lbs)[1]
W3500 Gas	Automatic	11,050	14,050
W4500 Gas	Automatic	14,050	17,050
W3500 Diesel	Automatic	12,000	18,000
W3500 Diesel	Manual	12,000	18,000
W4500 Diesel	Automatic	14,500	19,500
W4500 Diesel	Manual	14,500	20,500
W5500 Diesel	Automatic	16,500	19,500
W5500 Diesel	Manual	16,500	22,500
FSR, FTR, FVR	Automatic	[3, 4]	[3, 4]

A) The W3500/W4500 Gas/Diesel are not approved for Hot Shot type applications.

B) Allison AT 542 automatic GCWR is restricted to 22,050 lbs.

C) Allison AT 545 automatic GCWR is restricted to 30,000 lbs.

D) See FSR, FTR and FVR section

GENERAL INFORMATION

The following table provides the rear frame height for each model/GVWR with standard and optional tires:

Model	GVWR (lbs.)	Standard Tire	Frame HT (in.) FH Std. Tires
W3500 Gas	11,050	215/85R-16E	32
W4500 Gas	14,050	225/70R-19.5F	32.75
W3500 Diesel	12,000	215/85R-16E	32
W4500 Diesel	14,500	215/85R-16E	32
W5500 Diesel	16,500	225/70R-19.5F	32.75
FSR, FTR, FVR	2)	2)	2)

A) This is for 191” WB. The 148” WB and 167” WB have 32.9” frame height due to tapered frame.
B) Refer to FSR, FTR & FVR section.

Clutch Engagement Torque Chart

Engine	Torque (lbs-ft)	at (RPM)
GM/Isuzu 4HE1-TC (142 HP)	260	1,000
GM/Isuzu 4HE1-TC (175 HP)	265	1,000
GM/Isuzu 6HK1-TC (200 HP)	331	1,000
GM/Isuzu 6HK1-TC (230 HP)	368	1,000

PAINT CODE NUMBERS FOR 1987–1995 W3500/W4500

Sherwin-Williams Company and Inmont Corporation have developed paint specifications to match the 1987-1995 models. All have supplied paint code numbers to their jobers Rogers or Martin-Senour for Sherman-Williams and Rinshed-Mason for Inmont.

Sherwin-Williams		
GM/Isuzu Code	Color Name	Sherwin Code
0172-P1	Glacier White	35478

Acrylic Enamel Formula				
Stock #	1 Qt.	2 Qt.	3 Qt.	1 Gal.
F5R108	0.3	0.5	0.8	1.1
F5L68	1.2	2.3	3.5	4.7
F5Y107	2.1	4.3	6.4	8.6
F5B81	5.1	10.2	15.3	20.4
F5W110	399.0	798.0	1197.0	1596.0
V6V175	444.0	888.0	1332.0	1776.0
V2V269	1018.0	2036.0	3054.0	4072.0

Acrylic Lacquer Formula				
Stock #	1 Qt.	2 Qt.	3 Qt.	1 Gal.
L4R304	0.4	0.09	1.3	1.7
L4L305	0.9	1.7	2.6	3.5
L4B302	1.9	3.9	5.8	7.8
L4Y351	3.0	6.1	9.1	12.1
L4W301	952.0	190.4	2856.0	3808.0

Inmont		
GM/Isuzu Code	Color Name	Inmont Code
0172-P1	Glacier White	RM 15602

Acrylic Enamel Formula				
Stock #	1 Qt.	2 Qt.	3 Qt.	1 Gal.
PNT-90	80.2	160.4	240.5	320.7
AT-190	726.8	1453.7	2180.5	2907.3
AT-142	754.2	1508.4	2262.5	3016.7
AT-184	758.7	1517.4	2276.1	3034.8
AT-138	761.4	1522.8	2284.1	3045.5
AT-100	955.6	1911.2	2866.8	3822.4

PAINT CODE NUMBERS FOR 1995.5–1999 W3500/W4500

Arc White			
GM/Isuzu Paint Code	**GM/Isuzu Option Code**	**Sherwin-Williams Code**	**BASF Code**
W301-P801-0	729	51400	RM 25318

Accuride White*			
GM/Isuzu Paint Code	**GM/Isuzu Option Code**	**Sherwin-Williams Code**	**BASF Code**
301 W 30102	TBD	51548	RM 25319

* Wheel Color for 1999 N/W Series Gas models + produced in Janesville, Wisconsin.

PAINT CODE NUMBERS FOR 1997–1998 F SERIES MODELS (ZY1 PAINT SCHEME)

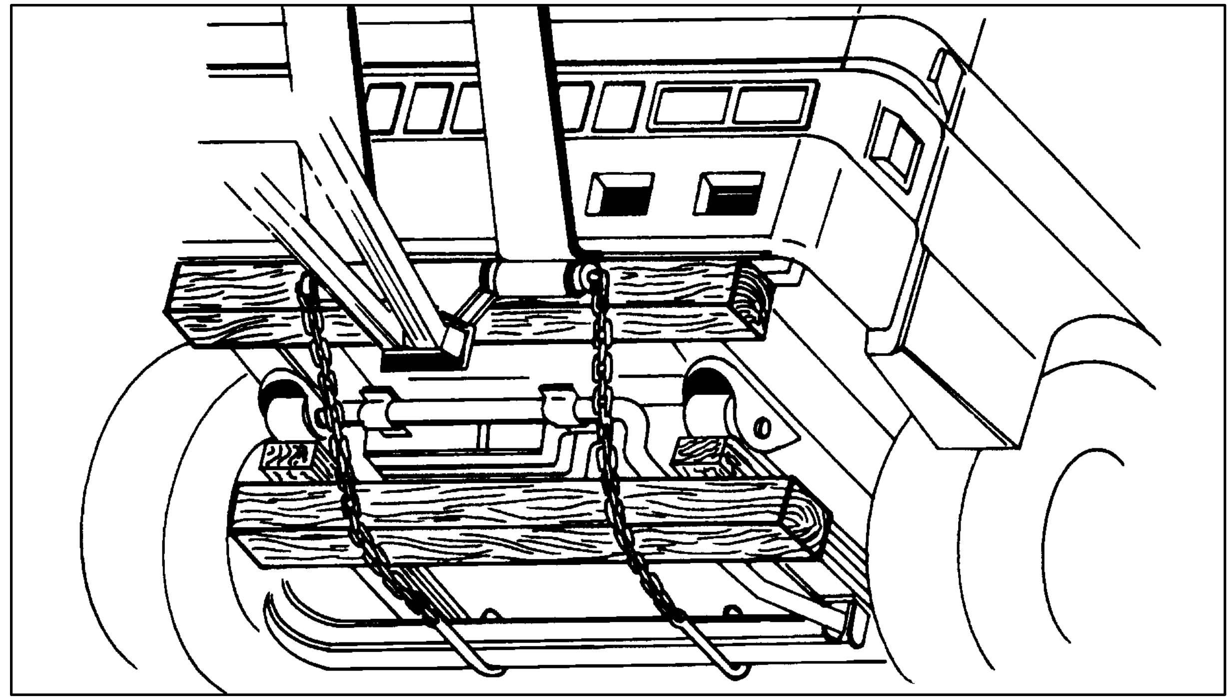
Arc White			
GM/Isuzu Paint Code	**GM/Isuzu Option Code**	**Sherwin-Williams Code**	**BASF Code**
W301-P801-0	729	51400	RM 25318

Gray/(Light Argent Fenders)			
GM Paint Code	**GMC/GM/Isuzu Option Code**	**Sherwin-Williams Code**	**BASF Code**
WE 5398	None	47155	RM 23009

W3500, W4500, W5500 TOWING PROCEDURE

Should it become necessary to tow the W3500, W4500 and W5500, the following procedure should be followed:

1. For manual transmission models, disconnect the propshaft at the rear axle or transmission. Secure the propshaft to the frame or crossmember.
2. For automatic transmission models, move the selector into “N” position, vehicles can be towed at speeds below 30 mph and up to distances less than 50 miles. If it is necessary to exceed these speeds or distances, the rear axle shafts must be removed or utilize rear end towing procedures.
3. Attach “J” hooks to the front axle inboard of the front spring.
4. Position a 4” x 4” timber or spacer under the front bumper reinforcement and another 4” x 4” timber with spacer blocks (as illustrated) under the front spring.
5. Position the tow bar under the bumper.
6. Attach safety chains to the front springs.
7. If the truck is loaded, the front bumper should also be removed.
8. Refer to Owner’s Manual in glove box for additional information.



WEIGHT DISTRIBUTION

A truck as a commercial vehicle has but one purpose. That purpose is to haul some commodity from one place to another. A short distance or a long distance, the weight to be hauled, more than any other factor, determines the size of the truck. A small weight requires only a small truck; a large weight requires a large truck. A simple principle, but it can easily be misapplied. In any case, selecting the right size truck for the load to be hauled will ensure that the job will be done and that is will be able to be done with some degree of reliability and within the legal limitations of total gross weight and axle gross weights.

Not only must a truck be selected that will handle the total load, but the weight must also be properly distributed between the axles. This is of extreme importance from both a functional and economic aspect. If a truck consistently hauls less than its capacity, the owner is not realizing full return on his investment and his operating costs will be higher than they should be. If the truck is improperly loaded or overloaded, profits will be reduced due to increased maintenance costs and potential fines resulting from overloading beyond legal limitation. Careful consideration must be given to distribution of the load weight in order to determine how much will be carried on the rear axle, on the trailer axles and the total. Moving a load a few inches forward or backward on the chassis can mean the difference between acceptable weight distribution for the truck or an application that will not do the job satisfactorily.

Every truck has a specific capacity and should be loaded so that the load distribution is kept within Gross Axle Weight Ratings (GAWR) and the truck’s Gross Vehicle Weight Rating (GVWR) or Gross Combination Weight Rating (GCWR) for a tractor/trailer and the weight laws and regulations under which the truck will operate. Improper weight distribution will cause problems in many areas:

1. Excessive front end wear and failure
   a. Tie-rod and king pin wear
   b. Front axle failure
   c. Overloading of front suspension
   d. Wheel bearing failure

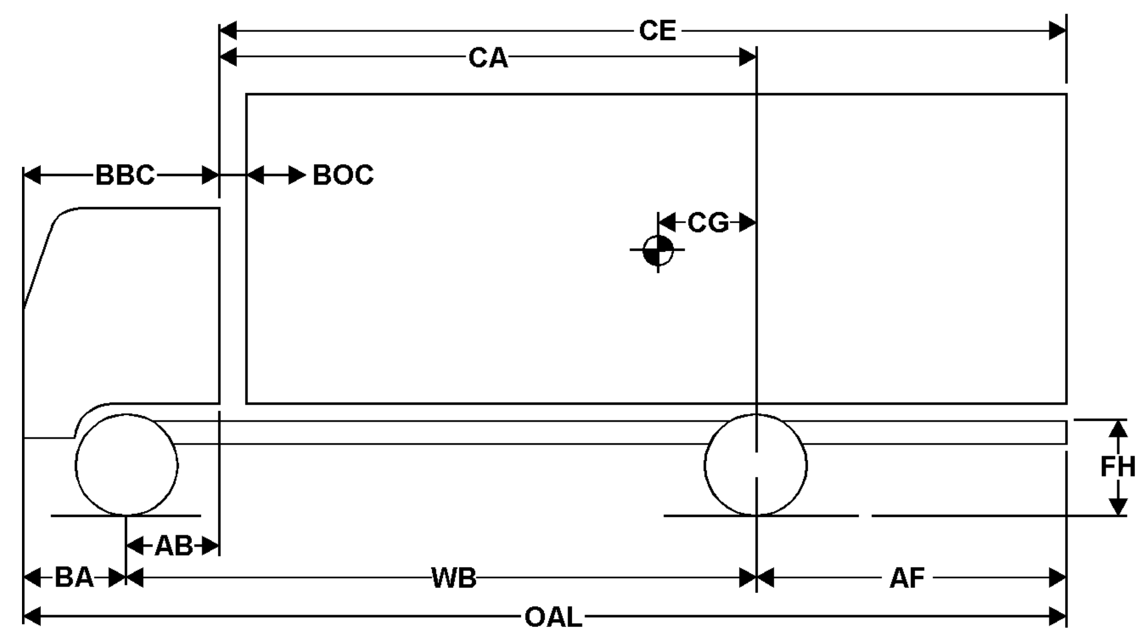
2. Rapid tire wear
   a. When the weight on a tire exceeds its rating capacity, accelerated wear will result and could result in tire failure.
3. Rough, erratic ride
   a. If the center of the payload is directly over or slightly behind the rear axle, the lack of sufficient weight on the front axle will create a bobbing effect, very rough ride, and erratic steering. This condition will be magnified when the truck is going up hill.
4. Hard steering
   a. When loads beyond the capacity of the front axle are imposed upon it, the steering mechanism is also overloaded and hard steering will result.
   b. Excessive overloading could result in steering component damage or failure.
5. Unsafe operating and conditions
   a. Poor traction on the steering axle effects the safety of the driver and equipment, particularly on wet, icy and slippery surfaces. Experience indicates that approximately 30% of the total weight at the ground on a truck or tractor should be on the front axle with a low cab forward vehicle.
   b. When a truck is overloaded, a dangerous situation may exist because minimum speeds cannot always be maintained, directional control may not be precise and insufficient braking capacity can cause longer than normal braking distances.
6. High maintenance costs
   a. Improper weight distribution and overloading cause excessive wear and premature failure of parts. Additional stresses impose on the frame by the misapplication of wheel bases, may be instrumental in causing the frame to crack or break.
7. Noncompliance with weight laws and regulations
   a. When there is the possibility that axle loads will exceed existing weight laws and regulations, careful weight distribution is necessary to provide a correct balance between front and rear axle loads, and total load within legal limitations.

In this way, maximum payloads may be carried without exceeding legal limits. If the body is too long for a wheelbase, the center of the body and payload is placed directly over the rear axle. This places all the payload on the rear axles, resulting in overlading the rear tires, rear axle springs and wheel bearings and potentially exceeding the rear axle legal weight limit. the front axle is then carrying no part of the payload and is easily lifted off the ground when going over rough terrain, creating a very rough ride and temporary loss of steering control If the body is too short for the wheelbase used, frame stress may be increased and may result in excessive loads on the front axle. Excessive front axle loads increase wear on the king pins and bushings, wheel bearings and steering gear. Excessive front axle loads also over stress the front axle, springs, tires and wheels. All of these contribute directly to higher maintenance costs and hard steering, both of which are undesirable.

WEIGHT DISTRIBUTION ANALYSIS involves the application of basic mathematical principles to determine the proper positioning of the payload and body weight in relation to the wheelbase of the truck chassis.

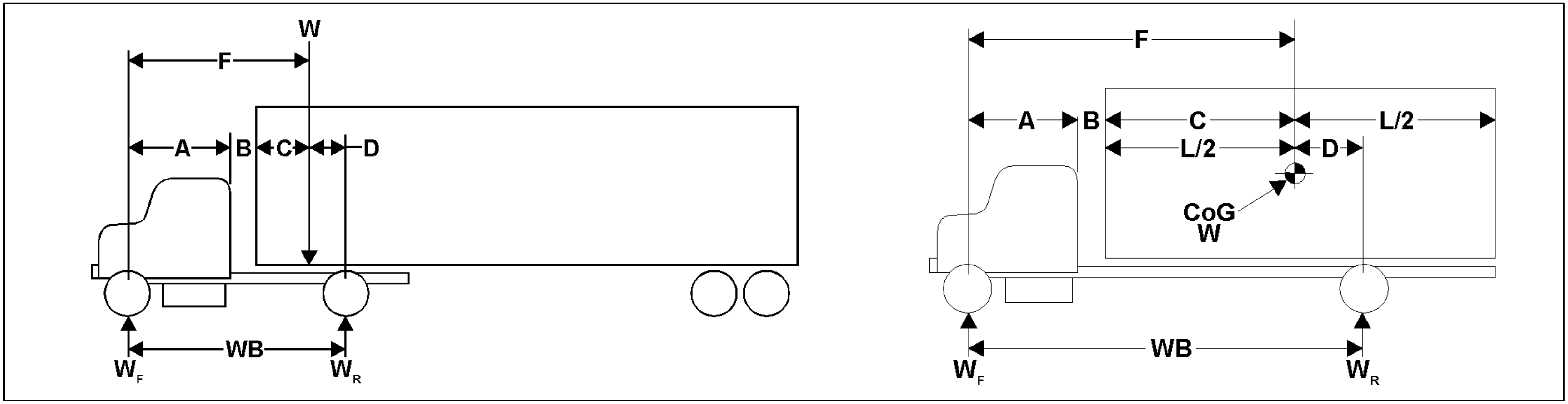
It is much less expensive to work all of this out on paper, make mistakes on paper and correct them there than to set up the truck incorrectly and either have it fail to do the job or much worse, fail completely.

It is important to become familiar with the dimensions of the truck as these will be needed to perform the necessary calculations.



BBC - Bumper to back of cab
BA - Bumper to axle
CA - Cab to axle
AB - Axle to back of cab
BOC - Back of cab clearance
CE - Cab to end of frame
CG - Center of gravity of body and payload from axle
WB - Wheelbase
OAL - Overall length
AF - Axle to end of frame
FH -Frame height

Weight Distribution Formulas



A - Front axle to back-of-cab
B - Distance between cab and body or trailer
C - Front of body to C.G. or front of trailer to kingpin
D - distance C.G. of body or fifth wheel is ahead of rear axle
F - (A + B + C) or distance C.G. of weight of fifth wheel is behind front axle
WB - Wheelbase
W - Weight of body plus payload, or kingpin load
W_f - Portion of W transferred to front axle
W_r - Portion of W transferred to rear axle

Basic Formulas

(a) $W \times D = W_f \times WB$

or

(b) $W \times F = W_r \times WB$

(c) $WB = (A + B + C + D) = (F + D)$

(d) $W = W_f \times W_r$

1. $W_f = \frac{W \times D}{WB}$

2. $D = \frac{W_f \times WB}{W}$

3. $WB = \frac{W \times D}{W_f}$

4. $W = \frac{W_f \times WB}{D}$

5. $W_r = \frac{W \times F}{WB}$

6. $F = \frac{W_r \times WB}{W}$

7. $WB = \frac{W \times F}{W_r}$

8. $W = \frac{W_r \times WB}{F}$

Weight Distribution Formulas in Words

To find:

1. Weight transferred to front axle = (Total weight) x (Distance C.G. is ahead of the rear axle
(Wheelbase)

2. Distance C.G. must be placed ahead of rear axle = (Weight transferred to the front axle) x (Wheelbase)
(Total weight)

3. Wheelbase = (Total weight) x (Distance C.G. is ahead of the rear axle)
(Weight to be transferred to the front axle)

4. Total Weight = (Weight to be transferred to the front axle) x (Wheelbase)
(Distance C.G. is ahead of the rear axle)

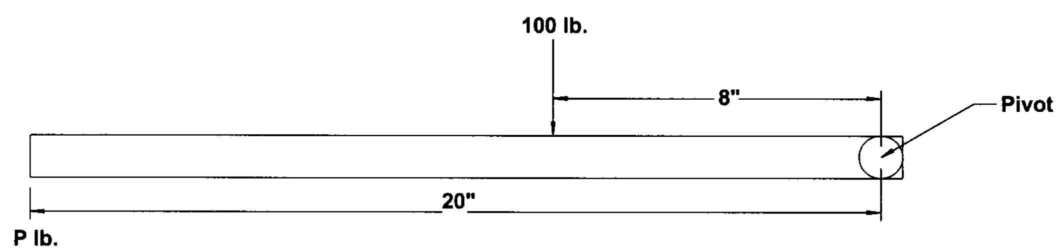
5. Weight transferred to the rear axle = (Total weight) x (Distance C.G. is behind the front axle)
(Wheelbase)

6. Distance C.G. must be placed behind the front axle = (Weight transferred to the rear axle) x (Wheelbase)
(Total weight)

7. Wheelbase = (Total weight) x (Distance C.G. is behind the front axle)
(Weight to be transferred to the rear axle)

8. Total weight = (Weight to be transferred to the rear axle) x (Wheelbase)
(Distance C.G. is behind the front axle)

9. Remember = Total weight must always equal weight transferred to the rear axle plus the weight transferred to the front axle

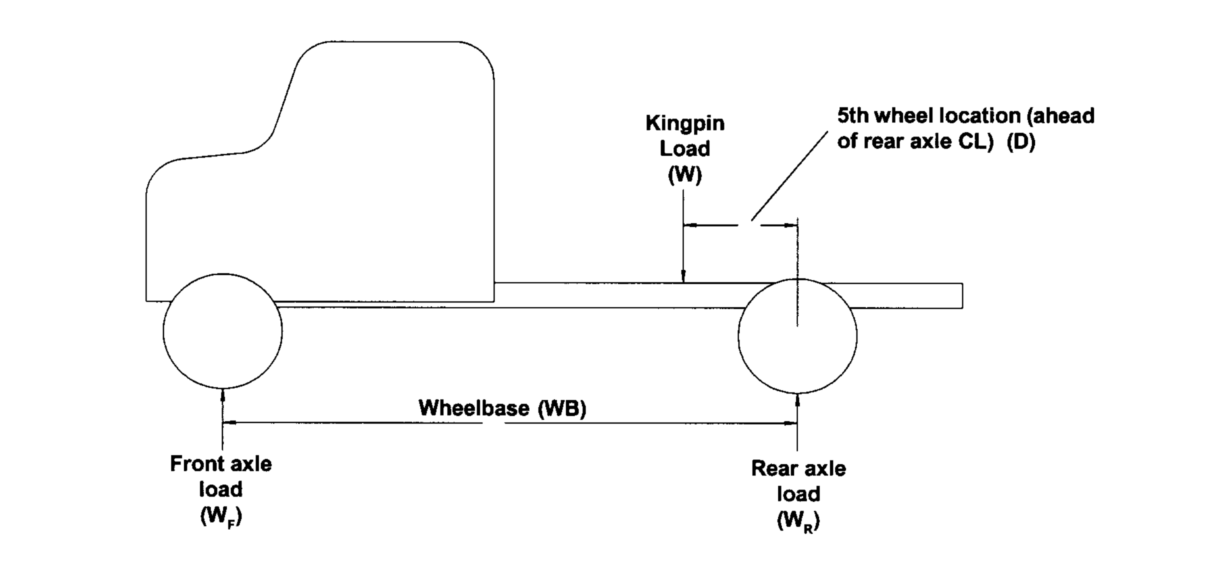


To find the value of "P", the leverages must be equal for balance.
i.e.
100 lb. x 8 in.= "P" x 20 in.
or

"P" = 100 lb. x 8 in.
20 in.

Therefore:
"P" = 40 lb.

This same approach is used to determine axle loadings on a tractor or truck chassis. Assuming the rear axle serves as a pivot point, the front axle load can be determined by applying the lever principle.



Front Axle Load: = $\frac{\text{Kingpin Load x 5th Wheel Location}}{\text{Wheelbase}}$

Rear Axle Load: = Kingpin Load–Front Axle Load

(4) A tractor has a wheelbase of 150 in. If the kingpin load is 20,000 lb. and the fifth wheel location is 15 in., find the total weight on the front and rear axles. The tare weight of the tractor is 7,000 lb. on the front axle and 4,400 lb. on the rear axle.

Front Axle	=	Load
20,000 x 15	=	2,000 lb.
150		
WB		

Rear Axle Load	=	20,000 – 2,000
	=	18,000 lb.

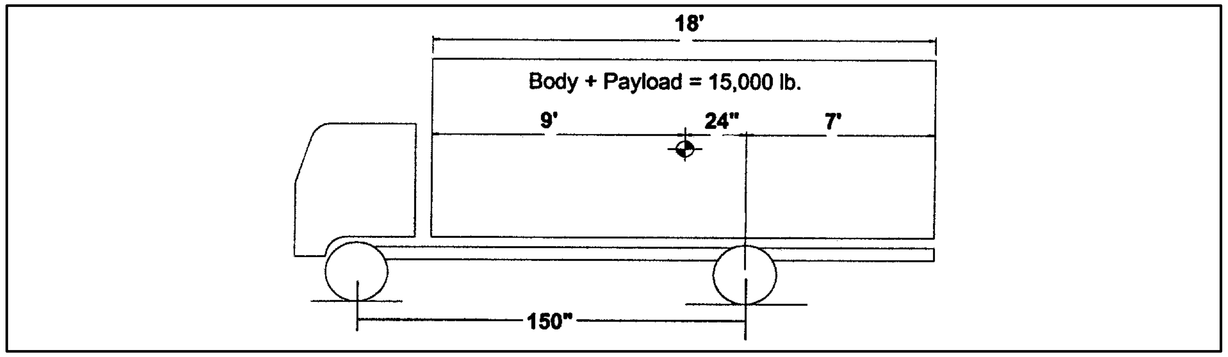
Therefore:

Total Front Axle Weight	=	2,000 + 9,000 lb.
Total Rear Axle Weight	=	4,400 + 18,000 lb.
	=	22,400 lb.

In calculating the weight distribution for a truck, the same lever principle is applied; however, there is one change in the initial consideration of the method of loading the truck body. Instead of the trailer kingpin location ahead of the rear axle center line, we must determine the position of the center of gravity of the payload and body weight in relation to the rear axle center line.

For our calculations we assume that the payload is distributed in the truck body so that the load is supported evenly over the truck body floor (water level distribution). The weight of the body itself is also considered to be evenly distributed along the truck frame. In this manner we can add the payload and body weights together and calculate the distribution on the vehicle chassis as an evenly distributed load on the truck frame rails.

So that we can make the necessary calculation in a simple manner, the total body and payload weight is considered to act at the center of gravity which will be at the center of the body length.



Example:

Front Axle Load =
$\frac{\text{(Body Weight + Payload) x C of G location}}{\text{Wheelbase}}$

Rear Axle Load =
(Body Weight + Payload) – Front Axle Load

Therefore, Front Axle Load =
$\frac{15{,}000 \times 24}{150}$ = 2400 lb.

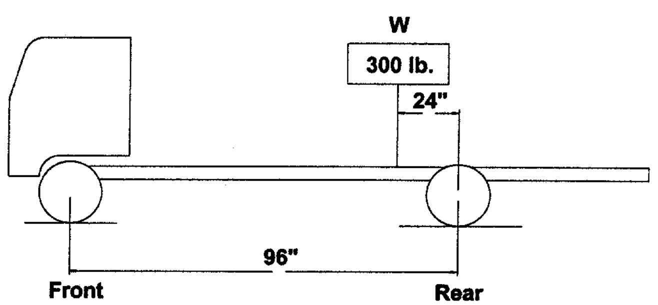
Fear Axle Load = 15,000 – 2,400 = 12,600 lb.

If the truck tare weight without the body is 5,000 lb. on the front axle and 2,400 lb. on the rear axle, then
Total Front Axle Weight = 5,000 + 2,400 = 7,400 lb.
and
Total Rear Axle Weight = 2,400 + 12,600 = 15,000 lb.

This same lever principle is applied in all calculations of weight distribution, whether we are dealing with concentrated loads as with a kingpin load acting on a fifth wheel or if it be with an evenly distributed load as with a truck body. The same approach is made in calculating an evenly distributed load on a trailer.

In the case of a tractor/trailer or a tractor with a set of doubles or triple trailers, each units is handled as a separated unit and then combined to determine the total.

This simple example illustrates how the principles are applied. Using the formulas, find the weight distributed to each axle.



Front Weight

A. $W_f = \frac{W \times D}{WB}$

B. $\frac{300 \times 24}{96}$

C. = 75 lb.

Rear Weight

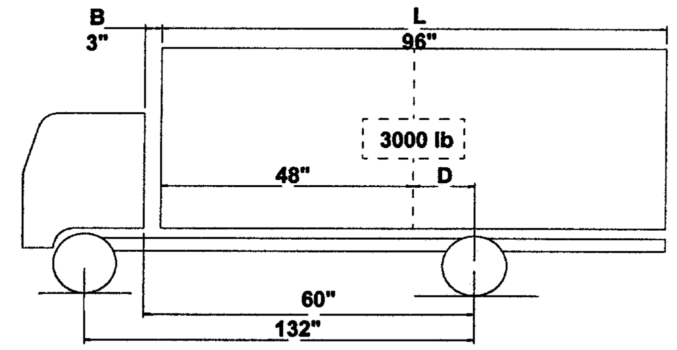
A. Total Weight–

B. 300 – 75

C. = 225 lb.

The body manufacturer can provide the body length and weight, or actual measurements of the body may be taken with a tape. Generally, (D) is unknown. This you must find logically, or with a tape measure.

Find (D) and then solve for W_f and W_r



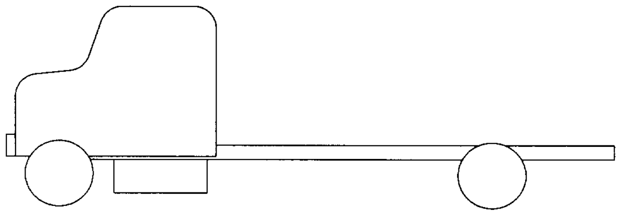
D = 60–3–48 = 9 in.

W_f = 205

W_r = 2,795

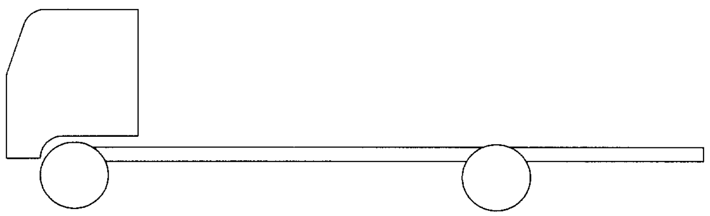
General Information

Recommended Weight Distribution % of Gross Vehicle Weight by Axle



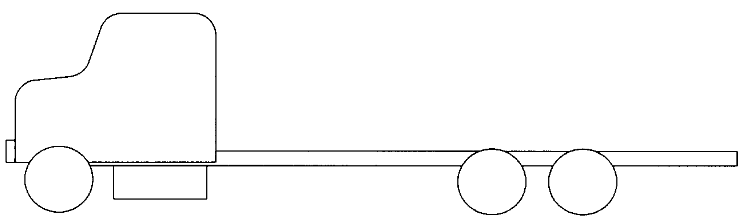
CONVENTIONAL (2 Axle)

	Front Axle	Rear Axle
Desired	25%	75%
Permissible	20-30%	70-80%



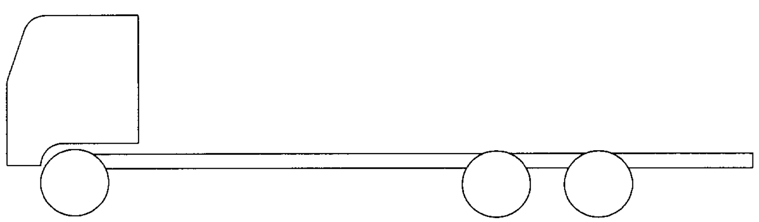
COE (2 Axle)

	Front Axle	Rear Axle
Desired	33 1/3%	66 2/3%
Permissible	30-35%	65-70%



CONVENTIONAL (3 Axle)

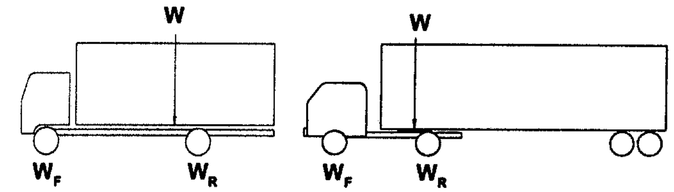
	Front Axle	Rear Axle
Desired	20%	80%
Permissible	18-25%	75-82%



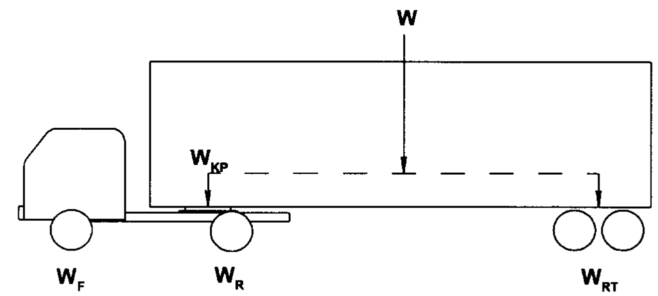
COE (3 Axle)

	Front Axle	Rear Axle
Desired	25%	75%
Permissible	20-30%	70-80%

Calculating tractor/trailer weight distribution can be thought of in the same terms as calculating full trucks.

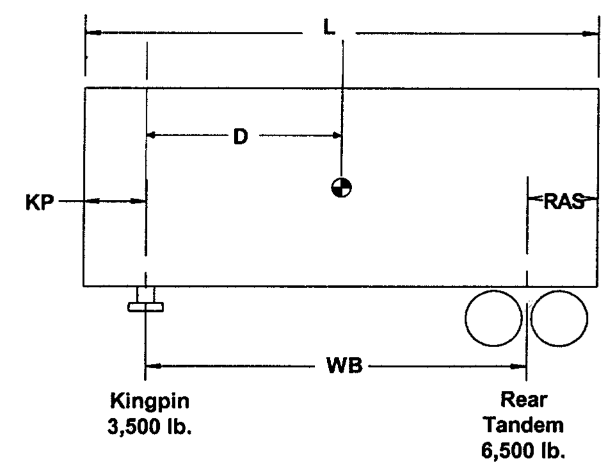


The weight at the center of the body and the load when applied is the same as the single point load of the kingpin on the fifth wheel.

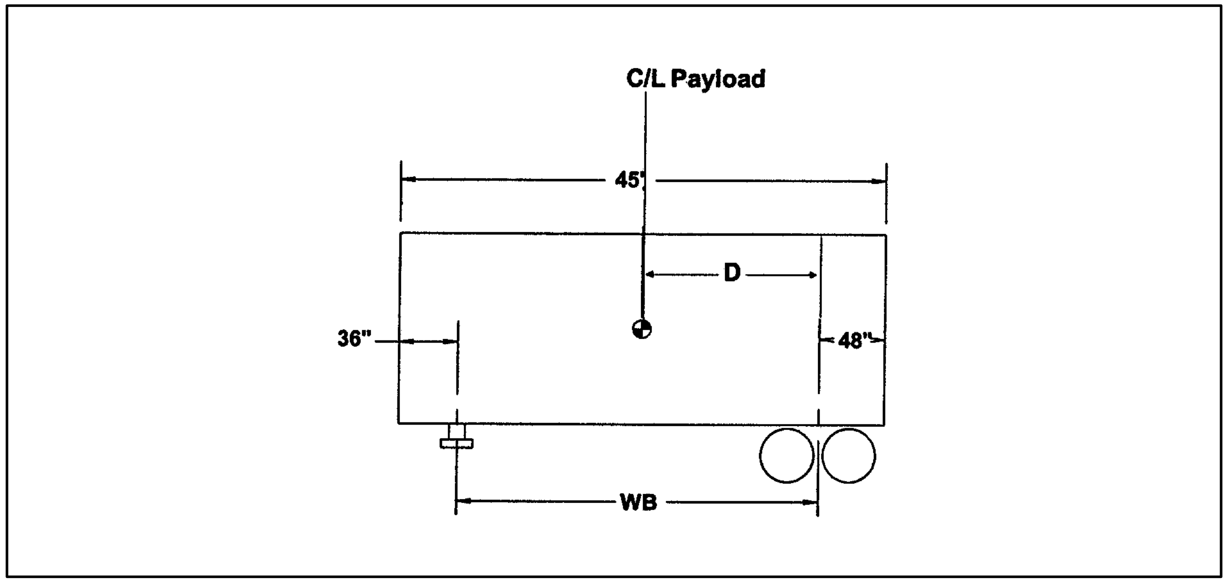


TRAILER WEIGHT

Fill in:
- L = 40 feet
- RAS = 48 in.
- KP = 36 in.
- WB = <u>396</u>
- D = <u>204</u>



In the following example, a 50,000 pound payload at water level loading. Calculate the payload (PL) weight transfer to kingpin and the rear axle.



Payload at Kingpin

$$PL_{kp} = \frac{W \times D}{WB}$$

Calculate the "D" dimension

OAL/2 – AF = D
45 feet/2 – 48 inches = 222 inches

$$PL_{kp} = \frac{50{,}000 \text{ lb.} \times 222 \text{ in.}}{456 \text{ in.}} = 24{,}342 \text{ lb.}$$

PL_{kp} = 24,342 lb.

Payload at Rear Tandem

$PL_{rt} = W – PL_{kp}$

PL_{rt} = 50,000 lb. – 24,342 lb. = 25,658 lb.

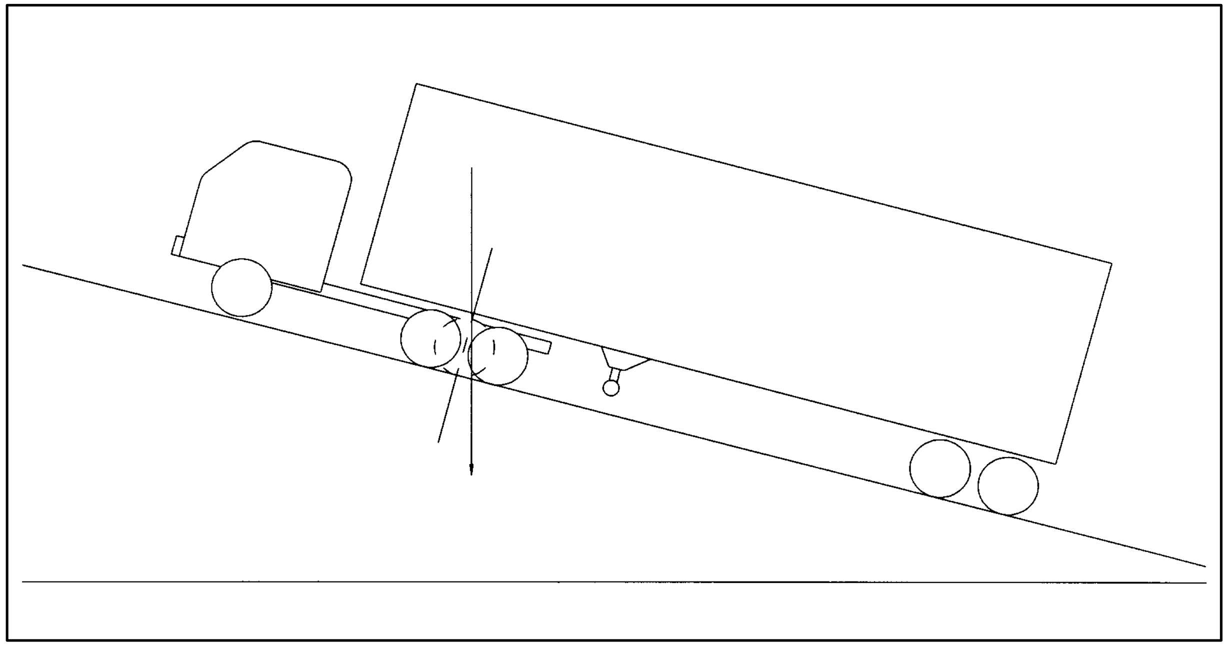
PL_{rt} = 25,658 lb.

Once the weight on the kingpin is determined, it can then be treated on the tractor the same as a weight on a straight truck.

Due to the variations in hauling and wheelbase requirements from one truck application to another, there is no one specific 5th wheel setting that will apply in all cases.

A "rule of thumb" which has proven satisfactory in many cases sets the 5th wheel one inch ahead of the rear axle for each 10 inches of wheelbase. In the case of tandem axles, the wheelbase is measured from the center line of the front axle to the midpoint between the tandem rear axles. The location of the 5th wheel fixes the load distribution between the front and rear axles. Too far forward and the front axle is overloaded. If too far back, the front axle may be too lightly loaded and cause an unsafe steering and braking control situation at the front axle.

A tractor on a hill with the 5th wheel set at the axle center line or too close to it will result in an unsafe handling situation by transferring too much weight to the rear axle and actually unloading the front axle



Performance Calculations

The following calculations have been included to help you determine the performance characteristics required by their customers and to select the appropriate model vehicle:

Speed Formula

This formula can be used to determine:

1. Top speed of the vehicle.
2. Speed in a given gear.
3. Final ratio required for a given speed.

$$\text{MPH @ Governed Speed} = \frac{(60) \times (\text{RPM})}{(\text{Rev/Mile}) \times (\text{Gear Ratio})}$$

Definitions in formulas:

RPM	=	Revolutions per minute of the engine
Rev/Mile	=	Tire revolutions per mile
Gear Ratio	=	The product of the axle ratio times the transmission ratio
60	=	Time Constant

Example:

W3500 Diesel 12,000 GVWR automatic transmission.

RPM	=	3,000
Rev/Mile	=	674
Gear Ratio	=	.703 x 5.375

$$\text{MPH @ Governed Speed} = \frac{(60) \times (3000)}{(674) \times (.703 \times 5.375)}$$

MPH @ Governed Speed = 70 MPH

Grade Horsepower Formula

This formula can be used to determine horsepower required for a given grade and speed.

$$\text{Horsepower Req'd. for a given grade} = \frac{\text{GVWR} \times \text{Grade} \times \text{Speed}}{37{,}500 \times \text{Efficiency Factor}} + \text{AHP}$$

GVWR	=	Gross Vehicle Weight Rating
Grade	=	Grade anticipated in percent
Speed	=	Speed in miles per hour
37,500	=	Constant
Efficiency Factor	=	Factor for losses in drivetrain due to friction (use 0.9 for a 90% efficient driveline)
AHP Resistance	=	Horsepower required to overcome wind force

Example:

W3500 Gas 11,050 GVWR automatic transmission with a van body.

GVWR	=	12,000 lbs.
Grade	=	1 percent
Speed	=	55 MPH
37,500	=	Constant
Efficiency Factor	=	0.9
AHP Resistance	=	53.6 HP (see the following formula for calculation)

$$\text{HP Required for Grade} = \frac{12{,}000 \times 1 \times 55}{37{,}500 \times 0.9} + 53.67$$

HP Required for Grade = 73.22

Air Resistance Horsepower Formula

This formula is used to determine the horsepower required to overcome air resistance at a given speed.

$$\text{Air Resistance Horsepower} = \frac{\text{FA} \times \text{Cd} \times (\text{MPH})^3}{156{,}000}$$

Definitions in formulas:

FA	=	Frontal area of vehicle in square feet
Cd	=	Aerodynamic Drag Coefficient
MPH	=	Speed of vehicle in miles per hour
156,000	=	Constant

Frontal area is calculated by multiplying the height of the vehicle by the width of the vehicle and subtracting the open area under the vehicle from the total.

Aerodynamic Drag Coefficients *(Source Material: Motor Truck Engineering Handbook):*

0.70	for most trucks, semitrailer combinations with tanks or van bodies
0.77	for double and triple trailers and flatbeds with loads
1.00	car and boat haulers

Example:

W3500 Diesel 12,000 GVWR van body with 96” wide, 115” high (84” body height + 31” frame height)

FA	=	$\frac{(96)}{(12)} \times \frac{(115)}{(12)} - 3.2$
FA	=	73.47 $FT.^2$
Cd	=	0.70
Speed	=	55 MPH
Air Resistance HP	=	$\frac{73.47 \times 0.70 \times (55)^3}{156{,}000}$
Air Resistance HP	=	54.85

Engine Horsepower Formula

This formula can be used to derive the output at a given RPM and torque.

$$\text{Horsepower} = \frac{\text{Torque} \times \text{RPM}}{5252}$$

Definitions in Formulas:

Torque	=	Twisting output of engine given in lb-ft
RPM	=	Revolutions per minute of engine
5252	=	Constant

Example:

W3500 12,000 GVWR automatic transmission.

Torque	=	347 lb-ft
RPM	=	2000
132 HP	=	$\frac{(347) \times (2000)}{5252}$

Gradeability Formula

This formula can be used to determine how large of a grade a vehicle can climb.

$$\text{Percent Grade} = \frac{1200 \times (T) \times (E) \times (C) \times (R)}{\text{GVWR} \times r} - RR$$

Definitions in formulas:

1200	=	Constant
T	=	Maximum Torque of Engine
E	=	Engine Efficiency (0.9)
C	=	Driveline Efficiency (0.9)
R	=	Transmission Ration x Axle Ratio
RR	=	Rolling Resistance (see following chart)
GVWR	=	Gross Vehicle Weight Rating
r	=	Loaded radius of tire

Example:

W3500 Diesel 12,000 GVWR automatic transmission on concrete highway.

T	=	347 lb-ft.
E	=	0.9
C	=	0.9
R	=	.703 x 5.375 (in overdrive)
RR	=	1.0
GVWR	=	12,000
r	=	14.1 in.
Percent Grade	=	$\frac{1200 \times (347) \times (0.9) \times (0.9) \times (.703) \times (5.375)}{12{,}000 \times 14.1} - 1.0$
Percent Grade	=	6.53 – 1
Gradeability	=	5.53%

Road Rolling Resistance			
Road Tolling Resistance – Expressed in Percent Grade			
Road Surface	**Grade**	**Road Surface**	**Grade**
Concrete, excellent	1.0	Cobbles, ordinary	5.5
Concrete, good	1.5	Cobbles, poor	8.5
Concrete, poor	2.0	Snow, 2 inch	2.5
Asphalt, good	1.25	Snow, 4 inch	3.75
Asphalt, fair	1.75	Dirt, smooth	2.5
Asphalt, poor	2.25	Dirt, sandy	3.75
Macadam, good	1.5	Mud	3.75 to 15.0
Macadam, fair	2.25	Sand, level soft	6.0 to 15.0
Macadam, poor	3.75	Sand, dune	16.0 to 30.0

Startability Formula

This formula is used to determine what type of a grade a vehicle can be started on.

$$\text{Startability} = \frac{(1200) \times (CET) \times (E) \times (C) \times (R)}{(GVWR \times r)} - 10\%$$

Definitions in formulas:

1200	=	Constant
CET	=	Clutch Engagement Torque
E	=	0.9
C	=	0.9
R	=	Transmission x Axle Ratio
10%	=	Average break away resistance and static inertia constant
GVWR	=	Gross Vehicle Weight Rating
r	=	Loaded radius of tire

Example:

W3500 Diesel 12,000 GVWR manual transmission.

CET	=	260 lb-ft
R	=	6.02 x 4.10
GVWR	=	12,000 lb.
r	=	14.1 in.

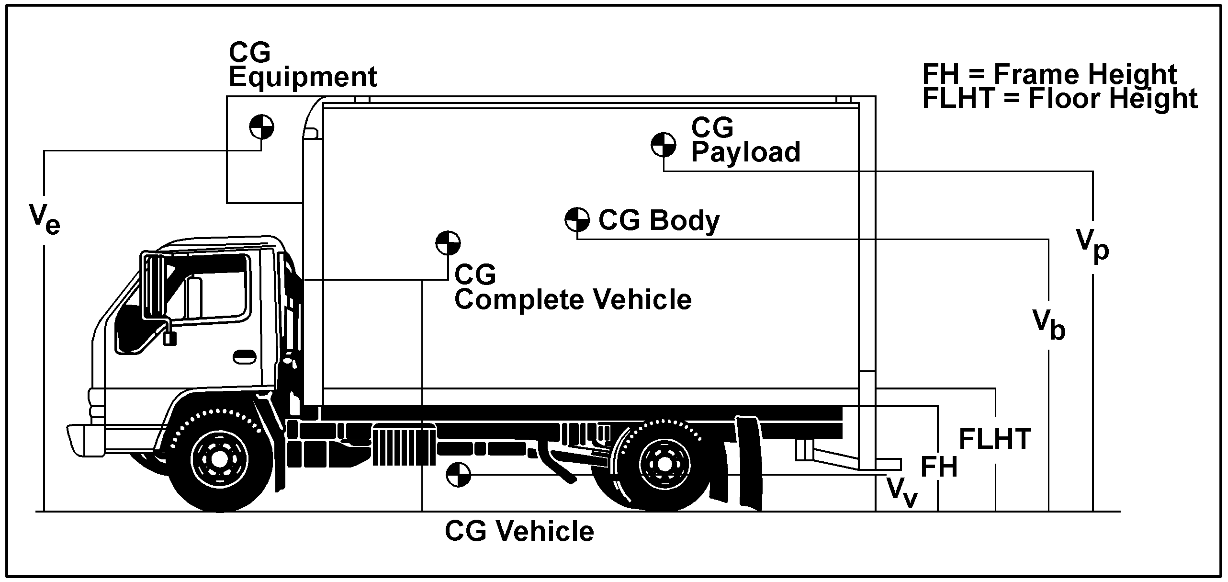
$$\text{Startability} = \frac{(1200) \times (260) \times (0.9) \times (0.9) \times (6.02 \times 4.10)}{(12{,}000 \times 14.1)} - 10\%$$

Startability = 26.86%

Vertical Center of Gravity Formula

These formulas are used to estimate the vertical center of gravity of a completed vehicle in order to determine whether maximum allowable limits have been exceeded. This formula should be used when encountering high center of gravity loads.

A. Wv x (Vv) = Mv
B. Wb x (Vb) = Mb
C. Wp x (Vp) = Mp
D. We x (Ve) = Me
E. $VCg = \frac{(Mv + Mb + Mp + Me)}{(Wv + Wb + Wp + We)}$



Definitions in formula:

VCg	=	The total average vertical center of gravity of the completed vehicle (vehicle, body, payload and equipment
Wv	=	Weight of vehicle
Wb	=	Weight of body
Wp	=	Weight of payload
We	=	Weight of equipment
Vv	=	Distance from ground to center of gravity of the vehicle
Vb	=	Distance from ground to center of gravity of the body
Vp	=	Distance from ground to center of gravity of the payload
Ve	=	Distance from ground to center of gravity of the equipment
Mv	=	Moment of vehicle
Mb	=	Moment of body
Mp	=	Moment of payload
Me	=	Moment of equipment

Example:

W3500 Diesel 12,000 GVWR automatic transmission, 132” WB, 14’ body length, 84” high body, full payload of boxes stacked to a maximum height of 48” above the flooring.

Wv	=	5291 lbs. *(from vehicle specifications)*
Wb	=	2100 lbs. *(from body manufacturer)*
Wp	=	4609 lbs. *(GVWR – (Wv + Wb + We))*
Vv	=	24.9 *(from Body Builder’s Guide, W3500 Diesel Section)*
Vb	=	80 in. *(from body manufacturer)*
Vp	=	62 in. *(1/2 of payload height + frame height + height from frame to flooring)*
Mv	=	5291 x 24.9 = 131,746 lb-in *(from A above)*
Mb	=	2100 x 80 = 168,000 lb-in *(from B above)*
Mp	=	4609 x 62 = 285,758 lb-in

$$VCg = \frac{(131{,}746 + 168{,}000 + 285{,}758)}{(5291 + 2100 + 4609)}$$

$$VCg = \frac{(528{,}504)}{(12{,}000)}$$

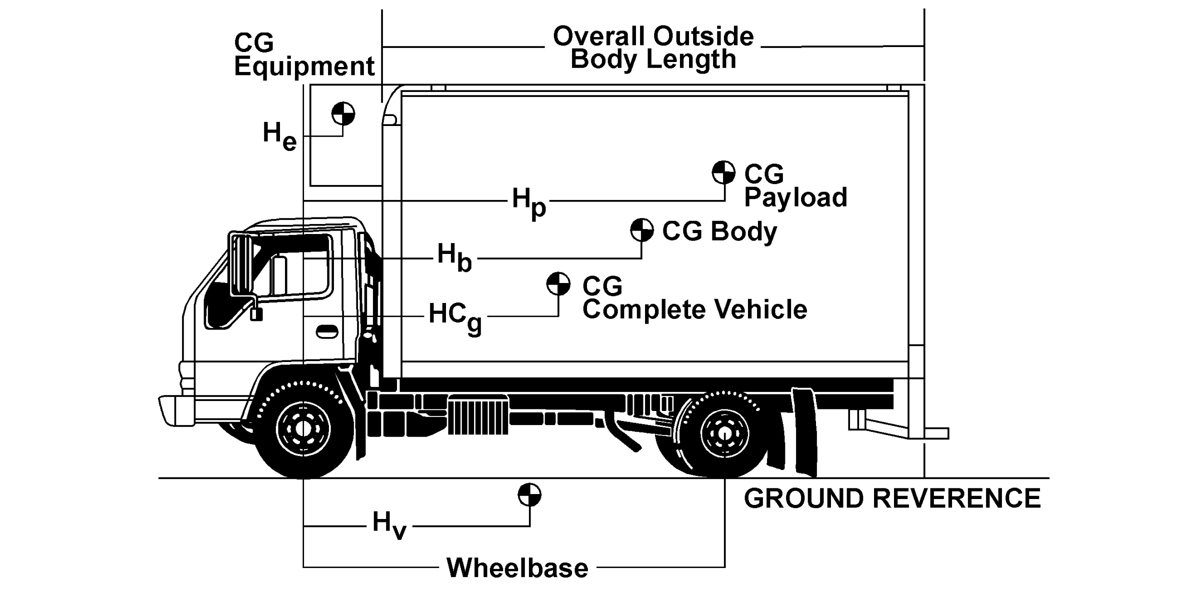
48.8 < 54.0 inches (54 inches is maximum allowable VCg per mfg. specifications from Body Builder’s Guide, W3500 Diesel section)

Since maximum VCg for this truck is not exceeded, 48” stack height above flooring is acceptable.

Horizontal Center of Gravity Formula

These formulas are used to estimate the horizontal center of gravity of a completed vehicle in order to determine whether it exists between the centerlines of the front and rear axles. This formula should be used when a load and/or permanent equipment (liftgate, reefer unit, snow plow, etc.) is installed on either extremes along the completed vehicle’s overall length.

A. Wv x (Hv) = Mv
B. Wb x (Hb) = Mb
C. Wp x (Hp) = Mp
D. We x (He) = Me
E. $HCg = \frac{(Mv + Mb + Mp + Me)}{(Wv + Wb + Wp + We)}$



Definitions in formula:

HCg	=	The total average horizontal center of gravity of the completed vehicle (vehicle, body, payload and equipment
Wv	=	Weight of vehicle
Wb	=	Weight of body
Wp	=	Weight of payload
We	=	Weight of equipment
Hv	=	Distance from front axle to center of gravity of the vehicle
Hb	=	Distance from front axle to center of gravity of the body
Hp	=	Distance from front axle to center of gravity of the payload
He	=	Distance from front axle to center of gravity of the equipment
Mv	=	Moment of vehicle
Mb	=	Moment of body
Mp	=	Moment of payload
Me	=	Moment of equipment

Example:

W3500 Diesel 12,000 GVWR automatic transmission, 132: WB, 14' body length, full payload of boxes stacked and distributed evenly throughout the flooring, 1,000 lb. reefer unit attached in front of body.

Wv	=	5291 lbs. *(from vehicle specifications)*
Wb	=	2100 lbs. *(from body manufacturer)*
Wp	=	3609 lbs. *(GVWR – (Wv + Wb + We))*
We	=	1000 lbs. *(from equipment manufacturer)*
Hv	=	42.4 in. *(from Body Builder's Guide, W3500 Diesel Section)*
Hb	=	107.5 in. *(from body manufacturer)*
Hp*	=	*107.5 in.* *(1/2 of payload length + distance from front axle to front of body)*
He	=	17.5 *(from equipment manufacturer)*
Mv	=	5291 x 42.4 = 224,338 lb-in *(from A above)*
Mb	=	2100 x 107.5 = 225,750 lb-in *(from B above)*
Mp	=	3609 x 107.5 = 387,967 lb-in *(from C above)*
Me	=	1000 x 17.5 = 17,500 lb-in *(from D above)*

$$HCg = \frac{(224{,}338 + 225{,}750 + 387{,}967 + 17{,}500)}{(5291 + 2100 + 3609 + 1000)}$$

$$HCg = \frac{(855{,}555)}{(12{,}000)} = 71.3 \text{ inches}$$

71.3 < 132 inches(132 inches is the wheelbase dimension)

Since HCg for this truck is not greater than the WB or negative (–), (denotes HCg forward of front axle centerline), it exists between the centerlines of the front and rear axles.

* Hp and Hb dimensions are the same in this example because CG of body and payload happen to be at the same point.

INTERSTATE HIGHWAY SYSTEM LIMITS

Bridge Gross Weight Formula

The Federal Government established the Federal Bridge Gross Weight Formula to provide a standard to control the spacing of truck axles on trucks that use highway bridges. This is intended to space loads out over a distance to avoid too high a concentration in one area that could cause damage. The truck's gross weights, axle weight and axle spacings are set in order to keep axle loads and gross weight loads with the limits set by the Federal Government. The Bridge Formula Table is used to check trucks to make sure that Federal weight limit requirements are met and that the allowable gross and axle weights are in the correct relationship with the spacing of axles to prevent high load concentrations on highway bridges.

The Federal Government has established the following formula to be used to determine the allowable weight limits and axle spacings for trucks.

$$W = 500 \left(\frac{LN}{N-1} + 12N = 36\right)$$

Where:

W = The total gross weight that may be carried on any group of two or more consecutive axles to the nearest 500 lb.

L = The distance (spacing) in feet between the outer axles of any group of two or more consecutive axles.

N = The number of axles in the group under consideration; except that two consecutive sets of tandem axles may carry a gross load of 34,000 lb. each provided the over-all distance between the first and last axles of such consecutive sets of axles in 36 feet or more.

Bridge Formula Definitions

The following definitions are used for bridge formula calculations.

Gross Weight:

The total weight of a truck (and/or trailer) combined with the weight of the load being hauled. The Federal gross weight limits on interstate highways and federal-aid highways and reasonable access is 80,000 lb.

Single Axle Weight

The total weight at the ground by all wheels of an axle whose centers may be included between parallel transverse planes forty inches apart, extending across the width of the truck. The Federal single axle weight limit on the Interstate system and reasonable access is 20,000 lb.

Tandem Axle Weight

The total weight at the ground of two or more consecutive axles whose centers may be included between parallel vertical places spaced more than forty inches but not more than ninety-six inches apart, extending across the full width of the truck. The Federal tandem axle weight limit on the Interstate system and reasonable access is 34,000 lb.

Consecutive Axle Weight

The Federal law stats that any two consecutive or more axles may not exceed the weight as computed by the formula even though the single axles, tandem axles, and gross weights are within the legal requirements.

Exception to the Bridge Formula

There is one exception to the use of the Federal Bridge Formula: Two consecutive sets of tandem axles may carry a gross load of 34,000 lb. each, providing the overall distance between the first and last axles of such consecutive set of tandem axles is 36 feet or more.

Other Federal Provisions

Maximum Width: 102" Overall

Length: States cannot set overall length limits on tractor, semitrailer or tractor – semitrailer, trailer combinations. States must allow tractors with double trailers. States must allow semitrailers of up to 48 feet in length for doubles combinations. There is also not limitation on overall length for semitrailer or doubles combinations.

These width and length dimensions apply to trucks operating on Interstate highways and federal-aid highways designed by the Federal Highway Administration. This also provides for reasonable access to the Interstate highways.

FEDERAL BRIDGE FORMULA TABLE

Distance in feet between the extremes of any group of 2 or more consecutive axles	Maximum Load in Pounds on any Group of 2 or More Consecutive Axles							
	2 Axles	3 Axles	4 Axles	5 Axles	6 Axles	7 Axles	8 Axles	9 Axles
4	34,000*							
5	34,000*							
6	34,000*							
7	34,000*							
8 and less	34,000*	34,000						
8 and more	38,000	42,000						
9	39,000	42,500						
10	40,000	43,500						
11		44,000						
12		45,000	50,000					
13		45,500	50,500					
14		46,500	51,500					
15		47,000	52,000					
16		48,000	52,500	58,000				
17		48,500	53,500	58,500				
18		49,500	54,000	59,000				
19		50,000	54,500	60,000				
20		51,000	55,500	60,500	66,000			
21		51,500	56,000	61,000	66,500			
22		52,500	56,500	61,500	67,000			
23		53,000	57,500	62,500	68,000			
24		54,000	58,000	63,000	68,500	74,000		
25		54,500	58,500	63,500	69,000	74,500		
26		55,500	59,500	64,000	69,500	75,000		
27		56,000	60,000	65,000	70,000	75,500		
28		57,000	60,500	65,500	71,000	76,500	82,000	
29		57,500	61,500	66,000	71,500	77,000	82,500	
30		58,500	62,000	66,500	72,000	77,500	83,000	
31		59,000	62,500	67,500	72,500	78,000	83,500	90,000
32		60,000	63,500	68,000	73,000	78,500	84,500	90,500
33			64,000	68,500	74,000	79,000	85,000	91,000
34			64,500	69,000	74,500	80,000	85,500	91,500
35			65,500	70,000	75,000	80,500	86,000	92,000
36			66,000+	70,500	75,500	81,000	86,500	93,000
37			66,500+	71,000	76,000	81,500	87,000	93,500
38			67,500+	72,000	77,000	82,000	87,500	94,000
39			68,000	72,500	77,500	82,500	88,500	94,500
40			68,500	73,000	78,000	83,500	89,000	94,500
41			69,500	73,500	78,500	84,000	89,500	95,000
42			70,000	74,000	79,000	84,500	90,000	95,500
43			70,500	75,000	80,000	85,000	90,500	96,000
44			71,500	75,500	80,500	85,500	91,000	96,500
45			72,000	76,000	81,000	86,000	91,500	97,500
46			72,500	76,500	81,500	87,000	92,500	98,000
47			73,500	77,500	82,000	87,500	93,000	98,500
48			74,000	78,000	83,000	88,000	93,500	99,000
49			74,500	78,500	83,500	88,500	94,000	99,500
50			75,500	79,000	84,000	89,000	94,500	100,000
51			76,000	80,000	84,500	89,000	95,000	100,500
52			76,500	80,500	85,000	90,500	95,500	101,000
53			77,500	81,000	86,000	91,000	96,500	102,000
54			78,000	81,500	86,500	91,500	97,000	102,500
55			78,500	82,500	87,000	92,000	97,500	103,000
56			79,500	83,000	87,500	92,500	98,000	103,500
57			80,000	83,500	88,000	93,000	98,500	104,000
58				84,000	89,000	94,000	99,000	104,500
59				85,000	89,500	94,500	99,500	105,000
60				85,500	90,000	95,000	100,500	105,500

* Tandem Axle by Definition

\+ Exception to Federal Bridge Formula Table and Law. See Text for Explanation.

NOTE: All permissible load calculations are to the nearest 500 lb. Maximum load on any single axle, 20,000 lb. Weights over 80,000 lb. are in excess of the Federal GVW on the National Highway Network.