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FMVSS AND CMVSS 105 and 135 HYDRAULIC BRAKE COMPLIANCE GUIDELINES FOR ALTERED RANGER VEHICLES AND E-SERIES VEHICLES (EXCEPT WHEN COMPLETED AS A SCHOOL BUS)

105 and 135 INFORMATION

Vehicle weight and dimensional information required for center of gravity calculations are available in the *Ford Source Book*. See your local Ford Dealer and refer to appropriate model year and specific vehicle for required information.

Abbreviated definitions and a vehicle diagram to assist with the equations for the FMVSS 105 and 135 segment are shown on page 57 for E-Series and Ranger and page 62 for Super Duty F-Series.

FOR ALL RANGER AND E-SERIES VEHICLES

The vehicle, as altered will conform to FMVSS and CMVSS No. 105 or 135, Hydraulic Brake System. if:

- No alterations, modifications or replacements are made to the service or parking brake system, anti-lock brake system, vacuum system, wheels or tires, brake system, indicator lamp and wiring, brake system reservoir labeling, suspension ride height or spring rate, hydro-boost system, power steering pump and lines if used with hydro-boost, and engine belt drive system.
- Any removal of a Ford body or chassis component is accompanied by the addition of equal weight.
- The vertical distance from the ground to the completed vehicle center of gravity should not exceed 36 inches for vehicles < 8000 lb GVWR and 48 inches for vehicles ≥ 8000 lb GVWR. (Restrictions for other standards may also apply).
- For Ranger Pickup Box Removal, the SUB weights found in Table A page 215 are met, as is the maximum Unloaded Vehicle Weight.
- The applicable GAWR's, GVWR, and accessory reserve capacity (ARC) weights (see preceding pages) are not exceeded.
- The applicable center of gravity limitations are met using one of the following calculation methods on this page.

FOR VEHICLES UNDER 3629 KG [8000 LB] GVWR

- The E-Series vehicle equipped with Recreational Trim have an Unloaded Vehicle Weight that does not exceed the values in Table 1 page 59.
- The rear weight component (W_{rul}), as measured between the rear tires and the ground, does not exceed 58% of the completed vehicle weight at Unloaded Vehicle Weight plus 400 lb located in the driver and front passenger area (W_{ul}).

Maximum $W_{rul} = .58 \times W_{ul}$ (see definitions on the next page).

- The horizontal center of gravity of the †SUB is rearward of †† L_{min} for the appropriate vehicle description in Table A on this page.

L_{min} does not apply to a SUB of 120 lb or less when installed rearward of the front seats and forward of the centerline of the rear axle. (Do not restrict seat travel. See IVM for SgRP location and torso angle).

The horizontal center of gravity for the SUB is:

- At or forward of the rear axle centerline. The vertical center of gravity for the completed vehicle at Unloaded Vehicle Weight + 400 lb passenger load CG_v (Equation A) must not exceed 36.0 inches, when measured from the ground.
- Behind the rear axle centerline. The vertical center of gravity of the completed vehicle at Unloaded Vehicle Weight + 400 lb passenger load must fall within the appropriate range determined from Table 6, page 60. The value of CG_h (Equation B), which approximates the horizontal center of gravity of the completed vehicle, is used in Table 6 page 60 to determine the vertical center of gravity limits for the completed vehicle. The value CG_v (Equation A), which approximates the vertical center of gravity of the completed vehicle, must fall within the appropriate range determined from Table 6 page 60.

EQUATION A

$$CG_v = \frac{CG_{vb}W_b + CG_{vc}W_c + 10,000}{W_t}$$

EQUATION B

$$CG_h = \frac{\left(W_{rb} + W_{rc} + \left(\frac{400 \times CG_{hp}}{WB} \right) \right)}{W_t} \times WB$$

FOR VEHICLES 3629 KG [8000 LB] THROUGH 8618 KG [19,000 LB] GVWR

The horizontal center of gravity for the SUB is:

- E-Series Van, Cutaway, and Stripped Chassis vehicles with a GVWR of 4536 kg [10,000 lb] or less do not exceed the maximum Unloaded Vehicle Weight value in Table 1 on page 59.
- E-Series Cutaways/Chassis Cab and Stripped Chassis vehicles conform to the minimum SUB weights found in Table 4 on page 60.
- At or forward of the rear axle centerline. The vertical center of gravity for the completed vehicle at GVWR (CG_v — Equation C) must not exceed 48 inches, when measured from the ground.
- E-250/350/450 Stripped Chassis, E350/450/550 Super Duty Cutaway/Chassis Cab must have a horizontal CG for the second unit body at or forward of the centerline of the rear axle.
- Behind the rear axle centerline. The vertical center of gravity for the completed vehicle at GVWR must fall within the appropriate range determined from Table 6 page 60. The value of CG_h (Equation D), which approximates the horizontal center of gravity of the completed vehicle, is used in Table 6 page 60 to determine the vertical center of gravity limits for the completed vehicle.

EQUATION C

$$CG_v = \frac{CG_{vb}W_b + CG_{vc}(W_c + W_l) + 25P}{GVWR}$$

EQUATION D

$$CG_h = \frac{\left(W_{rb} + W_{rc} + \left(\frac{P \times CG_{hp}}{WB} \right) + W_{rl} \right)}{GVWR} \times WB$$

TABLE A
HORIZONTAL CENTER OF GRAVITY FORWARD LIMIT

Vehicle	Wheelbase Millimeter [inch]	L_{min} Millimeter [inch]
E-150	3505 [138]	1473 [58]
E-250	3505 [138]	1524 [60]

TABLE B
E-SERIES PASSENGER LOAD

GVWR [lb]	P [lb]
8000 – 10,000	400
10,001 – 19,000	500

†SUB = Second Unit Body

(See definition next page.)

†† L_{min} = The minimum horizontal center of gravity of the SUB measured in inches rearward from the centerline of the front axle.

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- L^* = Horizontal distance in inches between the SUB center of gravity and the of the front axle.
- P = Passenger load [See Table B page 56.]
- CG_v = Vertical distance from the ground to the center of gravity [inches] of the completed vehicle.
- CG_h = Horizontal distance from of the front wheels to completed vehicle center of gravity [inches].
- CG_{vb} = Vertical distance from the ground to the center of gravity of the SUB and/or permanently attached equipment [inches].

- CG_{vc} = Vertical distance from the ground to the center of gravity of the chassis [inches] (including cab if original equipment). (Taken from Table 5, page 60.)
- CG_{hp} = Horizontal distance from the ground to the center of gravity of the of the front wheels to the P [inches] (passenger load). (Taken from Table 3, page 59.)
- W_b = Weight of the SUB and/or permanently attached added equipment [pounds].
- W_{rb} = Weight on the rear wheels of the SUB and/or permanently attached added equipment [pounds].
- W_{rc} = Weight at the rear wheels of the vehicle (chassis and cab) (fuel tanks full) [pounds], including option weight.

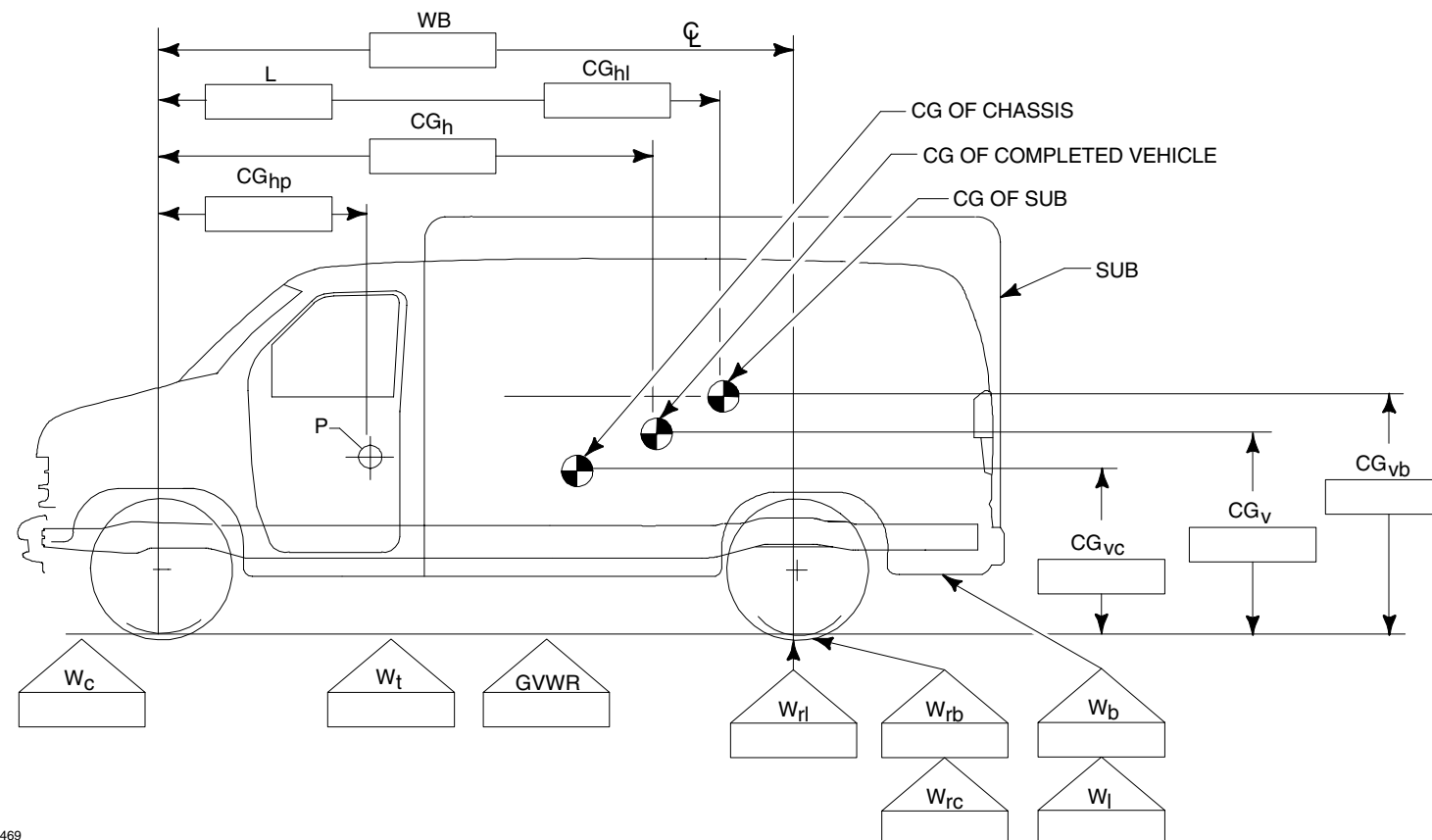
- W_c = Weight of the vehicle (chassis and cab) (fuel tanks full) [pounds], including option weight.
- WB = Vehicle wheelbase [inches].
- W_t = Total unladen weight = $(W_b + W_c + P)$
- $GVWR$ = Gross Vehicle Weight Rating of the vehicle [pounds].
- W_l^{**} = Remaining cargo capacity [pounds].
- Where: $W_l = GVWR - (W_b + W_c + P)$
- W_{rl}^{**} = Weight of the remaining cargo capacity on the rear wheels [pounds].

CG_{hl}^{**} = Horizontal distance from the of the front wheels to the cargo center of gravity [inches], (taken from Table 3, Page 59). For many common vehicles, if the CG_{hl} is not given in the table, then it may be estimated as the distance from the of the front wheel to the horizontal midpoint of the argo area.

SUB = A Second Unit Body consists of the body structure and/or all the cargo carrying, work performing and/or load bearing components and/pr equipment installed by a subsequent stage manufacturer on an incomplete vehicle, such that the incomplete vehicle becomes a completed vehicle.

- * Required for < 8000 lb GVWR calculations only.
- ** Required for ≥ 8000 lb GVWR calculations only.

$$W_{rl} = \frac{(CG_{hl}) W_l}{WB}$$



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SECOND UNIT BODY CENTER OF GRAVITY CALCULATION SUGGESTIONS

In the case where the rear weight of the SUB and/or added equipment must be reduced and the CG_v is found to be below the allowed minimum CG_v it may be possible to bring the vehicles into compliance by moving the CG_h forward. Forward movement of the CG_h can be accomplished by:

- Redistributing the weight of the SUB and/or added equipment.
- Adding **permanently** attached ballast forward of the CG_h . In order to reduce the rear weight, the ballast must be forward of the front axle. (Caution must be taken not to exceed the GVWR or front GAWR of the vehicle.)

The following general equations can be used to find the center of gravity of the SUB and added equipment when there are several elements making up the CG.

NOTE: Removal of the components or body parts would be represented by a negative weight being used in these calculations.

$$CG_{vb} = \frac{CG_{vb1}(W_{b1}) + CG_{vb2}(W_{b2}) + \dots + CG_{vbn}(W_{bn})}{W_{b1} + W_{b2} + \dots + W_{bn}}$$

and the horizontal CG location of the combined SUB and added equipment is:

$$CG_{hb} = \frac{(W_{rb1} + W_{rb2} + \dots + W_{rbn})WB}{W_{b1} + W_{b2} + \dots + W_{bn}}$$

The front/rear weight break down can be found with the use of the following equation:

$$W_{rb} = \frac{CG_{hb}(W_{b1} + W_{b2} + \dots + W_{bn})}{WB}$$

Conversely, the front weight component of the SUB and added equipment is:

$$W_{fb} = (W_{b1} + W_{b2} + \dots + W_{bn}) - W_{rb}$$

SAMPLE CALCULATIONS

Vehicles <8000 lb GVWR

Sample (1)

Ranger (4x2) pickup box removal vehicle 118 inch WB 4800 lb GVWR

Known:

$W_b = 250$ lb $W_{rb} = 260$ lb (behind rear axle)

$W_c = 2912$ lb; $W_{rc} = 1080$ lb

$CG_{vb} = 28$ $CG_{vc} = 25.5$ $CG_{hp} = 53.9$

This vehicle falls in the under 8000 lb GVWR category and the SUB CG is behind the rear axle.

From equation A & B.

$$CG_v = \frac{(28)(250) + (25.5)(2912) + 10000}{3562} = 25.6 \text{ inches}$$

$$CG_h = \frac{260 + 1080 + \frac{400 \times 53.9}{113.9}}{3562} \times 113.9 = 48.9 \text{ inches}$$

From Table 1, page 59:

Upper Limit $CG_v = 1.39 \times 48.4 - 36.8 = 31.2$ inches

Lower Limit $CG_v = 1.39 \times 48.4 - 51.7 = 16.3$ inches

The 25.6 inches calculated is within the range given so this vehicle is acceptable from a compliance to FMVSS and CMVSS 135 standpoint.

Sample (2)

E-Series under 8000 lb GVWR 138 inch WB

Altering a completed E-150 vehicle with the addition of a permanently attached tool box and partition can be handled as follows:

The vertical distance above the floor is

$$V = \frac{Wt1(CG_{1v}) + Wt2(CG_{2v})}{Wt1 + Wt2}$$

$$V = \frac{125(24) + 100(25)}{125 + 100} = 24.4 \text{ inches}$$

The longitudinal distance aft of the front axle is

$$L = \frac{Wt1(CG_{1h}) + Wt2(CG_{2h})}{Wt1 + Wt2} = \frac{125(133) + 100(63)}{125 + 100} = 101.9 \text{ inches}$$

Using the value for Min L from Table A on page 56:

$$\text{Min } L = .23(138) + 21.4 + .72(24.4)$$

$$\text{Min } L = 70.7 \text{ inches}$$

Since 101.9 is greater than 58, this meets the L_{MIN} criteria.

If the vehicle curb weight + 400 lb for passengers (before alteration) is: front = 2825 lb; rear = 1888 lb; and, total = 4713 lb, adding the alteration weight of 225 lb which is distributed as follows:

$$\text{Rear Axle Reaction} = \frac{225 + 101.9}{138} = 166 \text{ lb}$$

$$\text{Rear Axle Reaction} = 166 \text{ lb}$$

$$\text{Conversely the Front Axle Reaction} = 225 \text{ lb} - 166 \text{ lb} = 59 \text{ lb}$$

$$W_{rul} = 1888 \text{ lb} + 166 \text{ lb} = 2054 \text{ lb}$$

$$W_{ul} = 4713 \text{ lb} + 225 \text{ lb} = 4938 \text{ lb}$$

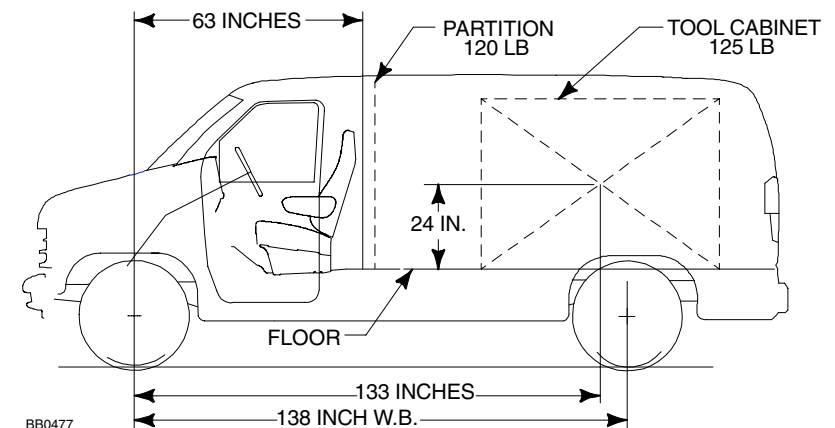
$$\text{Max } W_{rul} = (.58)(4938) = 2864 \text{ lb using equation from page 56}$$

So a W_{rul} of 2054 lb is less than the max.

W_{rul} , therefore, meets the criteria specified for compliance with FMVSS and CMVSS 105.

If the add-on weight of the SUB is forward of the centerline of the rear axle while conforming to GAWR, GVWR, ARC, and for pickup box removal vehicles min/max SUB weight restrictions (Table A page 215) are conformed to, then there are no FMVSS and CMVSS 135 issues.

**E-150 ALTERED COMPLETED VEHICLE
ADD TOOL CABINET AND A PARTITION**



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TABLE 1 Unloaded Vehicle Weight (UVW) This information Does Not Apply to Vehicles Over 4536 kg [10,000 lb]						
Models	Wheelbase Millimeter [inch]	MAXIMUM UNLOADED VEHICLE WEIGHTS Kilogram [pound] by Engine Size Liter [cubic inch]				
Incomplete E-Series Vehicles		4.2L [256] ⁽³⁾	4.6L [281]	5.4L [330]	6.8L [413]	7.3LD [444]
E-150 Regular Recreational Van	3505 [138]	2699 [5950] ⁽²⁾	2699 [5950] ⁽²⁾	2699 [5950] ⁽²⁾	NA	NA
E-250 Regular Recreational Van	3505 [138]	NA	NA	3130 [6900]	NA	NA
E-250 Comm. Stripped Chassis SRW	3150 [124]	2676 [5900]	NA	NA	NA	NA
E-350 Regular Van	3505 [138]	NA	NA	3583 [7900]	3583 [7900]	3583 [7900]
E-350 Extended Van or Extended Wagon	3505 [138]	NA	NA	3583 [7900]	3583 [7900]	3583 [7900]
E-350 Cutaway SRW ⁽¹⁾	3505 [138]	NA	NA	3856 [8500]	3856 [8500]	3856 [8500]
E-350 Cutaway DRW ⁽¹⁾	3505 [138]	NA	NA	3856 [8500]	3856 [8500]	3856 [8500]
E-350 Stripped Chassis SRW	3505 [138]	NA	NA	3946 [8700]	NA	NA
E-350 Stripped Chassis DRW	3505 [138]	NA	NA	3946 [8700]	NA	NA
E-350 Stripped Chassis SRW	4013 [158]	NA	NA	3946 [8700]	NA	NA
E-350 Stripped Chassis DRW	4013 [158]	NA	NA	3946 [8700]	NA	NA
E-350 Stripped Chassis DRW	4470 [176]	NA	NA	3946 [8700]	NA	NA
⁽¹⁾ E-350 vehicles completed as a School Bus must be equipped with the School Bus Prep Package and the Unloaded Vehicle Weight must exceed: – 2540 kg [5600 lb] with single rear wheels (SRW). – 2858 kg [6300 lb] with dual rear wheels (DRW). ⁽²⁾ 2767 kg [6100] when completed with 6 or less designated seating positions ⁽³⁾ Maximum unloaded vehicle weight values shown in this table are limits for purposes of FMVSS conformity only. The frontal area of the completed vehicle may limit the Maximum Unloaded Vehicle Weight based on emission certification with the 4.2L engine. See the chart on page 62 for additional information.						

TABLE 2 CG _{hl} = Horizontal distance from front axle cargo CG:		
Model	WB [in]	CG _{hl} [in] †
Super Duty F-Series:		
Regular Cab	137.0	132
Regular Cab	140.8	134
Regular Cab	164.8	146
Regular Cab	188.8	158
Regular Cab	200.8	164
SuperCab	158.0	153
SuperCab	161.8	155
Crew Cab	172.4	165
Crew Cab	176.2	167
Crew Cab	200.2	182
E-Series:		
Regular Van	138	116
†Extended Van or Extended Wagon	138	126
†Cutaway (SRW)	138	121
(DRW)	138	127
†Commercial Cab/Box Partition (DRW)	158	134
†RV (DRW)	158	138
†Commercial No Partition (DRW)	158	143
†RV (DRW)	176	153
†Commercial (DRW)	176	160
†E-550 (DRW)	159.5	145
	177.5	154
	191.5	167
	209.5	182
	233.5	203
† If CG _{hl} is not given in the table or if the location of your cargo is not in the normal cargo area, then your CG _{hl} may be estimated as the distance from the \mathcal{C} of the front wheel to the horizontal midpoint of the cargo area.		

TABLE 3 CG _{hp} = Horizontal distance from front wheel \mathcal{C} to Passenger Load. [Dimensions are in inches.]	
All Rangers	53.9
All Super Duty F-Series	61.2
All E-Series † (except E-550)	48.5
E-550	50.0
† Except E-Series Stripped Chassis where the distance from the \mathcal{C} of the front axle to the H-point of the driver must be measured.	

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TABLE 4 MINIMUM SUB WEIGHT	
Models	Kilogram [pound]
E-350 Cutaway/Chassis Cab 3505 mm [138 in] WB	689 [1520]
E-350 Cutaway/Chassis Cab 4013 mm [158 in] WB	826 [1820]
E-350 Cutaway/Chassis Cab 4470 mm [176 in] WB	962 [2120]
E-450 Cutaway/Chassis Cab 4013 mm [158 in] WB	826 [1820]
E-450 Cutaway/Chassis Cab 4470 mm [176 in] WB	962 [2120]
E-550 Cutaway/Chassis Cab 4051 mm [159.5 in] WB	1234 [2720]
E-550 Cutaway/Chassis Cab 4058 mm [177.5 in] WB	1370 [3020]
E-550 Cutaway/Chassis Cab 4864 mm [191.5 in] WB	1506 [3320]
E-550 Cutaway/Chassis Cab 5321 mm [209.5 in] WB	1642 [3620]
E-550 Cutaway/Chassis Cab 5931 mm [233.5 in] WB	1778 [3920]
E-250 Stripped Chassis	771 [1700]
E-350 Stripped Chassis All WB	862 [1900]
E-450 Stripped Chassis All WB	998 [2200]

TABLE 5 CG _{vc} = Vertical distance ground to chassis CG [Dimensions are in inches.]	
Ranger (4x2)	= 24.0
Ranger (4x4)	= 27.0
F-150 (4x2)	= 26.0
F-150 (4x4)	= 28.5
F-250/350 (4x2) SRW > 8500 lb GVWR	= 30.0
F-250/350 (4x4) SRW > 8500 lb GVWR	= 31.0
F-350 (4x2) DRW	= 30.0
F-350 (4x4) DRW	= 31.0
F-450/550 (4x2 & 4x4) DRW	= 35.0
E-150 & E-250 Van < 8500 lb GVWR	= 28.5
E-250/350 SRW Van or Wagon > 8000 lb GVWR	= 32.0
E-350 Cutaway/Chassis Cab	= 28.0
E-450 Cutaway/Chassis Cab	= 26.5
E-550 Cutaway/Chassis Cab	= 29.5
E-250 SRW Stripped Chassis	= 25.0
E-350/450 Stripped Chassis	= 26.5

TABLE 6 CG _v = Vertical distance from the ground to the completed vehicle center of gravity [inch]. GVWR < 8000 lb use equation A & B, page 56				
Model	WB	Equation for CG _v Range		
		Upper Limit		Lower Limit
Ranger 4x2 GVWR ≤ 4580 lb	112	CG _v =	1.39 x CG _h – 34.8	1.39 x CG _h – 49.0
	118	CG _v =	1.39 x CG _h – 36.8	1.39 x CG _h – 51.7
	126	CG _v =	1.39 x CG _h – 40.3	1.39 x CG _h – 56.7
Ranger 4x2 GVWR ≥ 4580 lb	112	CG _v =	1.39 x CG _h – 36.0	1.39 x CG _h – 42.0
	118	CG _v =	1.39 x CG _h – 38.5	1.39 x CG _h – 44.6
	126	CG _v =	1.39 x CG _h – 45.5	1.39 x CG _h – 48.6
Ranger 4x4 GVWR ≥ 4580 lb	112	CG _v =	1.39 x CG _h – 32.8	1.39 x CG _h – 38.4
	118	CG _v =	1.39 x CG _h – 34.7	1.39 x CG _h – 40.5
	126	CG _v =	1.39 x CG _h – 38.0	1.39 x CG _h – 44.4
GVWR < 8000 lb use equation A & B, page 56 Place the CG _h of the vehicle (from equation B) into the appropriate equations below to determine the allowable range of the CG _v . If the actual CG _v (from equation A) is within the range calculated, the center of gravity location is acceptable.				
Model	WB	Equation for CG _v Range		
		Upper Limit		Lower Limit
E-150	138	CG _v =	1.39 x CG _h – 46.9	1.39 x CG _h – 58.7
E-250 7900 lb GVWR	138	CG _v =	1.39 x CG _h – 47.1	1.39 x CG _h – 59.0
GVWR ≥ 8000 lb use equation C & D, page 56 Place the CG _h of the vehicle (from equation D) into the appropriate equations below to determine the allowable range of the CG _v . If the actual CG _v (from equation C) is within the range calculated, the center of gravity location is acceptable.				
Model	WB	Equation for CG _v Range		
		Upper Limit		Lower Limit
E-250 8600 lb GVWR	138	CG _v =	1.27 x CG _h – 59.0	1.27 x CG _h – 77.5
E-350 (SRW) ≤ 9600 lb GVWR	138	CG _v =	1.27 x CG _h – 60.0	1.27 x CG _h – 80.0
	158	CG _v =	1.27 x CG _h – 69.5	1.27 x CG _h – 90.7