

Spicer® Steer Axles



SPICER®
Drivetrain Products

Application Guidelines

SAAG2012

July 2012

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Important Information about these *Guidelines*

Purpose

The purpose of these *Application Guidelines* is to provide original equipment manufacturer (OEM) builders of medium and heavy duty trucks with information about which Spicer® Steer Axle products are approved by Dana Commercial Vehicle Products (Dana CVP) for use in common vocational applications in the USA and Canada.

Use of Guidelines

These *Guidelines* apply to on-,on-off and off-highway axle applications and vocations in the USA and Canada. The *Guidelines* are classified by steer axle weight ratings. Steer axle selection and approval is based on GCW/GVW rating, GAWR, steering geometry, vehicle Track, tire size and spring mounting conditions. Vehicle applications that meet the specified vocation definitions and specified axle criteria are approved by Dana CVP for use within the applicable general requirements and recommendations without formal review by Dana CVP. Applications outside the specified vocations, duty cycles, ratings and all off-road applications must be reviewed and approved on an individual basis by the Dana CVP Application Engineering Department.

Warranties

Dana CVP's warranties for Steer axles are set out in the Dana Warranty Guide. Applications and installations must either meet the requirements of these *Guidelines* or be approved by the Dana CVP Application Engineering Department. Failure to obtain applications approval or the use of Spicer® axles or their components in non-approved applications will void the Dana CVP warranty coverage. Modification of the vehicle, changes in the vocational use, or service outside the limits of these *Guidelines* will void the Dana CVP warranty coverage. OEM assumes responsibility for system related dynamics that adversely affect product performance.

Questions

For answers to questions concerning these *Guidelines* or to request an Application Approval Request Form for a use not covered by these Guidelines, contact:

Dana Commercial Vehicle Products Group
3939 Technology Drive
Maumee, Ohio, USA 43537
Phone: (877) 777-5360

Changes to Guidelines

These *Guidelines* are subject to change at any time, without prior notice, at the discretion of Dana CVP.

Steer Axle Application *Guidelines* Sections

These *Guidelines* are divided up into 6 main sections:

1. Model Nomenclature and Exploded Views

Describes the Spicer Families of Steer Axles along with exploded views and a breakdown of the model designations.

2. Applications, Engineering Data

Detailed Engineering data including available steer arm options, tie rod arm options, tie rod geometry graphs, GAWR versus track, and camber / toe change due to loading.

3. Alignment/Adjustment

Graphically displays Steer Axle alignment details – showing caster, camber, toe, ackermann geometry, steering angle, and lubrication requirements.

4. Vocation Descriptions

Graphical and verbal descriptions of all approved vocations detailing duty cycles and vehicle types.

5. Application Approval Procedure

Details method of submitting an approval request for any application that falls outside the standard guidelines listed in section 2. This includes manual and automatic submission into our system. Also provides a link to instructions on how to use our Applications Database.

6. Glossary of Terms

Spicer® Steer Axles

1. Model Nomenclature and Exploded Views

E – Series Steer Axles Nomenclature

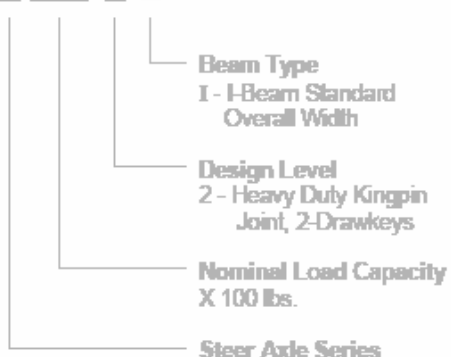
On-Highway / Line Haul / Regional Haul usage

Beam Type

I – I-Beam Standard Overall Width

W – I-Beam Wide Track over 96” OAW

E-120 2 I



I – Series Steer Axles Nomenclature

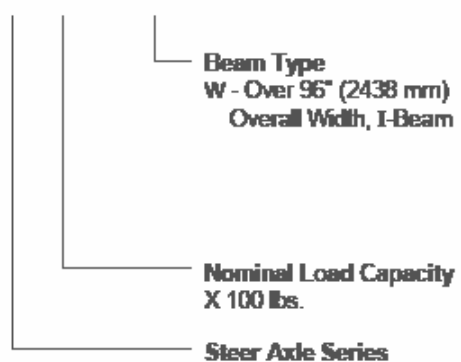
On/Off-Highway / Medium Duty / Regional Haul / Severe Duty usage

Beam Type

W – I-Beam Wide Track over 96” OAW

SG – Specialty Axle

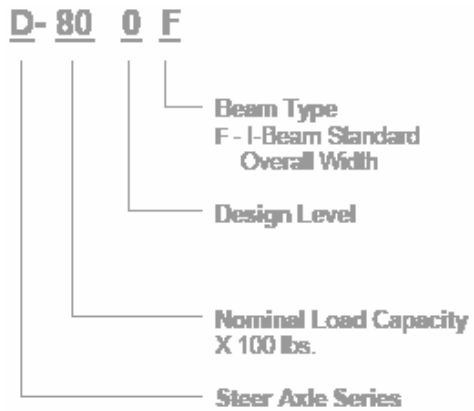
I-180 W



Spicer® Steer Axles

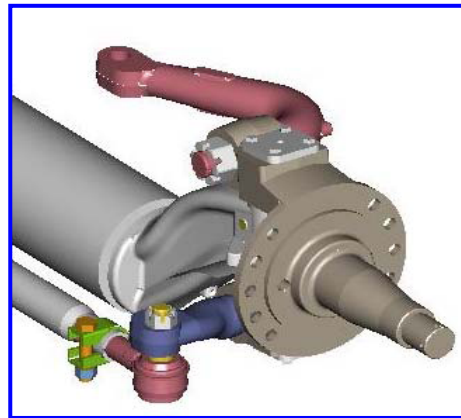
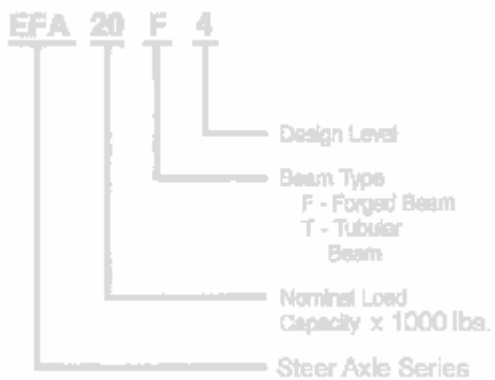
D – Series Steer Axle Nomenclature On-Highway / Medium Duty usage

Beam Type
F – I-Beam Standard OAW
W – I-Beam Wide Track over 96" OAW



EFA – Series Steer Axle Nomenclature On/Off-Highway / Severe Duty usage

Beam Type
F – Forged I-Beam
T – Tubular Beam

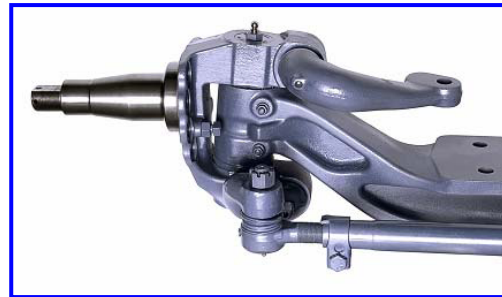
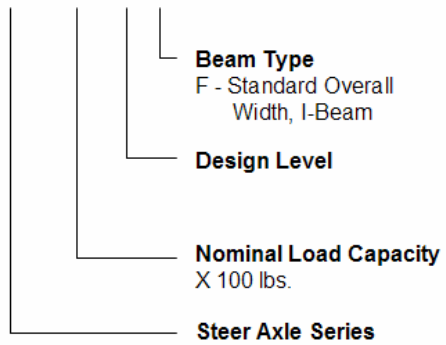


Spicer® Steer Axles

D-2000 – Series Steer Axle Nomenclature On/Off-Highway / Severe Duty usage

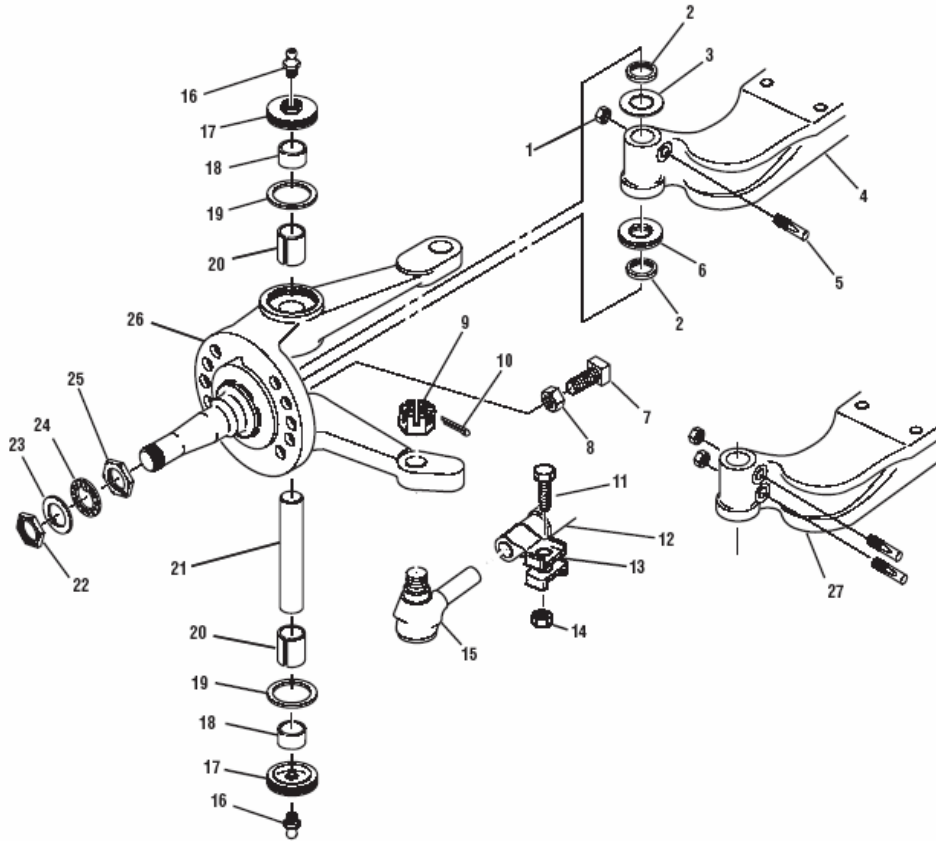
Beam Type
F – I-Beam Standard OAW

D - 200 0 F



Spicer® Steer Axles

E – Family Exploded View



1 - Nut, Draw Key

2 - Seal, Grease

3 - Shim

4 - Axle Beam

5 - Key, Draw

6 - Bearing, Thrust

7 - Screw, Stop

8 - Nut, Jam

9 - Nut, Slotted

10 - Pin, Cotter

11 - Bolt, Clamp

12 - Tube, Cross

13 - Clamp

15 - Tie Rod End

16 - Lube Fitting

17 - Cap, Knuckle

18 - Foam Insert

19 - Gasket

20 - Bushing

21 - Kingpin

22 - Nut, outer Spindle*

23 - Washer, Retainer*

24 - Washer, Spindle*

25 - Nut, Inner Spindle*

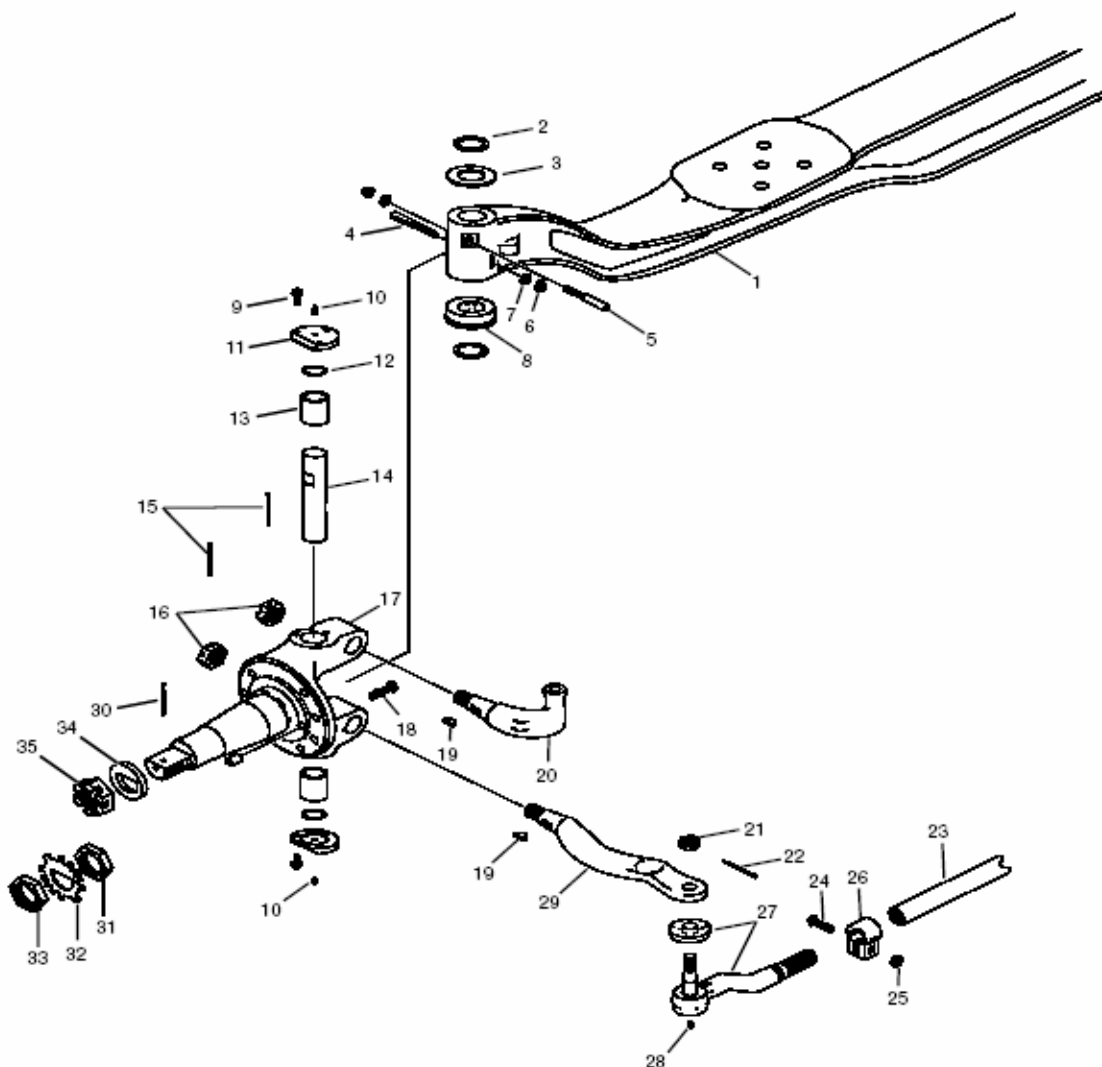
26 - Steering Knuckle

27 - Dual Draw Key Beam

* Nut, Pro-Torq (optional alternative for items 22-25)

Spicer® Steer Axles

I,D – Family Exploded View



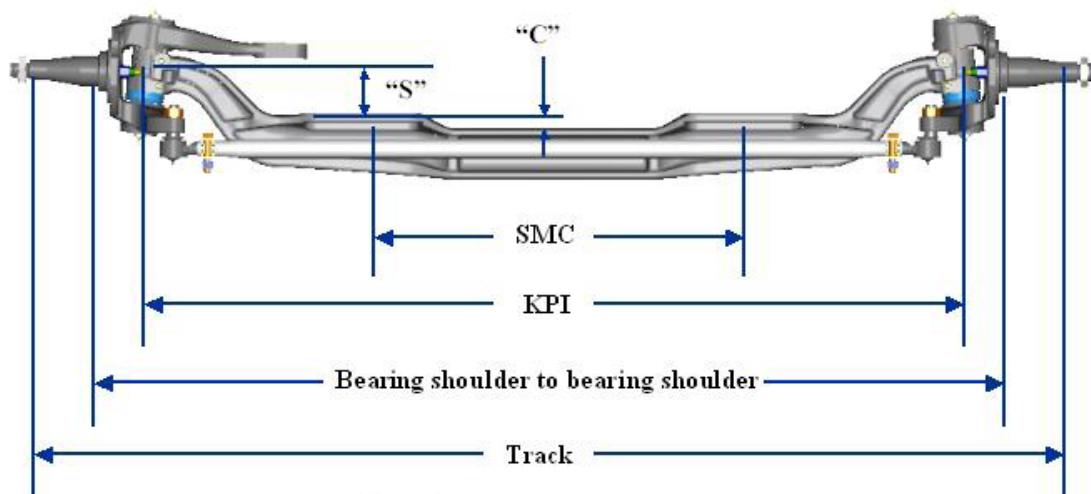
- | | | |
|------------------------------|--------------------------|-------------------------------|
| 1 - I-Beam | 13 - Bushing, Kingpin | 25 - Nut, Tie Rod Clamp |
| 2 - Seal, Kingpin | 14 - Kingpin | 26 - Clamp, Tie Rod |
| 3 - Shim | 15 - Pin, Cotter | 27 - Tie Rod End |
| 4 - Draw Key, Outer | 16 - Nut, Slotted | 28 - Grease Fitting |
| 5 - Draw Key, Inner | 17 - Knuckle, Steering | 29 - Arm, Tie Rod |
| 6 - Nut, Draw Key | 18 - Bolt, Stop | 30 - Pin, Spindle Cotter |
| 7 - Washer, Belleville | 19 - Key, Woodruff | 31 - Spindle Nut, Inner |
| 8 - Bearing Assembly, Thrust | 20 - Arm, Steering | 32 - Nut, Spindle Lock washer |
| 9 - Bolt, Kingpin Cap | 21 - Nut, Tie Rod | 33 - Spindle Nut, Outer |
| 10 - Grease Fitting | 22 - Pin, Cotter Tie Rod | 34 - Washer, Brg Retainer |
| 11 - Cap, Kingpin | 23 - Tube, Cross | 35 - Nut, Slotted Spindle |
| 12 - O-Ring | 24 - Bolt, Tie Rod Clamp | |

2. Applications, Engineering Data

The following chart shows all available Spicer Steer Axles with a brief Engineering description. Once you click on a model, you will be taken to an Engineering Data Information Sheet that will have details on the following: Beam Drop, Turn Angle, Kingpin, Wheel bearing adjustment, Weight, Ground clearance, Spring mounting centers, camber and kingpin angles, nominal ratings, maximum track, steering knuckles, axle center, kingpin intersection, overall width, bearing shoulder to bearing shoulder, wheel bearings, model identification, steering knuckle options, available steer arms, available tie rod arms, available spring pad drilling, axle rating specifications – GAWR versus track @ max tire SLR and nominal SMC.

Applications outside the specified vocations and duty cycles shown in section 4, as well as the ratings (ie: GAWR, track and wheelbase) shown below, must be reviewed on an individual basis by the Dana Commercial Vehicle Product Group Application Engineering Department (an example of an Engineering data sheet can be found on pg-[16]).

Engineering Data Information descriptive explanation



Beam drop

“S” = KP pivot to spring pad

“C” = KP pivot to center of beam

GAWR (lb.)	Models	Definition				Design Restriction
		Beam Drop (in) "S" "C"		KPI (in.)	Turn Angle Range ^o	
8000	D-800F	3.50	1.00	71.0	40-50	Max Track at rated load = 82" SMC = 31-35" for 3" spring Bearing Shoulder to Bearing Shoulder = 78.48" Overall Width = 96" nominal Max Tire SLR = 20.0" Max Power Steering torque = 28,450 lb.in.
	D-800W	3.50	1.00	72.0	40-50	Max Track at rated load = 83" SMC = 32-36" for 3" spring Bearing Shoulder to Bearing Shoulder = 79.48" Overall Width = 97" nominal Max Tire SLR = 20.0" Max Power Steering torque = 28,450 lb.in.
8500	D-850F	3.50	1.00	71.0	40-50	Max Track at rated load = 82" SMC = 31-35" for 3" spring Bearing Shoulder to Bearing Shoulder = 78.48" Overall Width = 96" nominal Max Tire SLR = 20.0" Max Power Steering torque = 28,450 lb.in.
	D-850W	3.50	1.00	72.0	40-50	Max Track at rated load = 83" SMC = 32-36" for 3" spring Bearing Shoulder to Bearing Shoulder = 79.48" Overall width = 97" nominal Max Tire SLR = 20.0" Max Power Steering torque = 28,450 lb.in.

GAWR (lb.)	Models	Definition				Design Restriction
		Beam drop (in) "S" "C"		KPI (in.)	Turn Angle Range°	
10000	E-1002I	3.50	1.25	69.0	22-55	Max Track at rated load = 81.5" SMC = 30-35" for 4" spring, 29-36 for 3" spring Bearing Shoulder to Bearing Shoulder = 77.38" Overall Width = 96" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
	E-1002W	3.50	1.25	71.0	22-55	Max Track at rated load = 83.5" SMC = 32-37" for 4" spring, 31-38 for 3" spring Bearing Shoulder to Bearing Shoulder = 79.38" Overall Width = 98" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
		3.74	1.25	71.5	22-55	Max Track at rated load = 84" SMC = 32.5-37.5" for 4" spring, 31.5-38.5 for 3" spring Bearing Shoulder to Bearing Shoulder = 79.88" Overall Width = 98.5" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
	I-100W	3.74	1.50	71.5	35-45 40-50	Max Track at rated load = 90.0" SMC = 32-36" for 4" spring Bearing Shoulder to Bearing Shoulder = 80.158" Overall width = 98.5" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.

GAWR (lb.)	Models	Definition				Design Restriction
		Beam drop (in) "S" "C"		KPI (in.)	Turn Angle Range°	
12000	E-1202I	3.50	1.25	69.0	22-55	Max Track at rated load = 81.5" SMC = 30-35" for 4" spring, 29-36" for 3" spring Bearing Shoulder to Bearing Shoulder = 77.38" Overall Width = 96" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
	E-1202W	3.50	1.25	71.0	22-55	Max Track at rated load = 83.5" SMC = 32-37" for 4" spring, 31-38" for 3" spring Bearing Shoulder to Bearing Shoulder = 79.38" Overall width = 98" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
	E-1202W	3.74	1.25	71.5	22-55	Max Track at rated load = 84" SMC = 32.5-37.5" for 4" spring, 31.5-38.5" for 3" spring Bearing Shoulder to Bearing Shoulder = 79.88" Overall width = 98.5" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
	I-120W	3.74	1.50	71.5	35-45 40-50	Max track at rated load = 89" SMC = 32-36" for 4" spring Bearing shoulder to bearing shoulder = 80.158" Overall width = 98.5" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.

GAWR (lb.)	Models	Definition				Design Restriction
		Beam drop (in) "S" "C"		KPI (in.)	Turn Angle Range ^o	
13200	E-1322I	3.50	0.86	69.0	22-55	Max track at rated load = 85.5" SMC = 31-36" for 4" spring, 30-37" for 3" spring Bearing shoulder to bearing shoulder = 77.38" Overall width = 96" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
		5.00	0.86	69.0	22-45	Max track at rated load = 85.5" SMC = 31-36" for 4" spring, 30-37" for 3" spring Bearing shoulder to bearing shoulder = 77.38" Overall width = 96" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
	E-1322W	3.50	0.86	71.0	22-55	Max track at rated load = 87.5" SMC = 31.5-38" for 4" spring, 30.5-39" for 3" spring Bearing shoulder to bearing shoulder = 79.38" Overall width = 98." nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
		3.74	0.86	71.5	22-55	Max track at rated load = 87.5" SMC = 32-38.5" for 4" spring, 31-39.5" for 3" spring Bearing shoulder to bearing shoulder = 79.88" Overall width = 98.5" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
		5.00	0.86	71.0	22-50	Max track at rated load = 87.5" SMC = 33-38" for 4" spring, 32-39" for 3" spring Bearing shoulder to bearing shoulder = 79.38" Overall width = 98" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.
14000	I-140W	3.74	1.50	71.5	35-45 40-50	Max track at rated load = 86.8" SMC = 32-36" for 4" spring Bearing shoulder to bearing shoulder = 80.158" Overall width = 98.5" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in.

GAWR (lb.)	Models	Definition				Design Restriction
		Beam drop (in) "S" "C"		KPI (in.)	Turn Angle Range ^o	
14600	E-1462I	3.50	0.86	69.0	22-50	Max track at rated load = 84" SMC = 31-36" for 4" spring, 30-37" for 3" spring Bearing shoulder to bearing shoulder = 77.38" Overall width = 96" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in. Dual Steer Arm required with TPCS
		5.00	0.86	69.0	22-50	Max track at rated load = 84" SMC = 31-36" for 4" spring, 30-37" for 3" spring Bearing shoulder to bearing shoulder = 77.38" Overall width = 96" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in. Dual Steer Arm required with TPCS
	E-1462W	3.50	0.86	71.0	22-50	Max track at rated load = 86" SMC = 31.5-38" for 4" spring, 30.5-39" for 3" spring Bearing shoulder to bearing shoulder = 79.38" Overall width = 98" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in. Dual Steer Arm required with TPCS
		3.74	0.86	71.5	22-50	Max track at rated load = 86" SMC = 32-38.5" for 4" spring, 31-39.5" for 3" spring Bearing shoulder to bearing shoulder = 79.88" Overall width = 98.5" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in. Dual Steer Arm required with TPCS
		5.00	0.86	71.0	22-50	Max track at rated load = 86" SMC = 33-38" for 4" spring, 32-39" for 3" spring Bearing shoulder to bearing shoulder = 79.38" Overall width = 98" nominal Max Tire SLR = 21.5" Max Power Steering torque = 43,050 lb.in. Dual Steer Arm required with TPCS
16000	I-160W	3.74	1.50	71.5	28-43 35-50	Max track at rated load = 85.25" Allow track at 32.5" SMC = 85.75" SMC = 32-36" for 4" spring Bearing shoulder to bearing shoulder = 81.02" Overall width = 102.36" nominal Max Tire SLR = 21.5" Max Power Steering torque = 58,850 lb.in. Dual Steer Arm required
18000	I-180W	3.74	1.50	71.0	28-43 35-50	Max track at rated load = 90.50" SMC = 32-36" for 4" spring Bearing shoulder to bearing shoulder = 80.52" Overall width = 102.36" nominal Max Tire SLR = 21.5" Max Power Steering torque = 58,850 lb.in. Dual Steer Arm required

GAWR (lb.)	Models	Definition				Design Restriction
		Beam drop (in) "S" "C"		KPI (in.)	Turn Angle Range ^o	
20000	I-200W	3.74	1.50	71.0	28-43 35-50	Max track at rated load = 88.35" SMC = 32-36" for 4" spring Bearing shoulder to bearing shoulder = 80.52" Overall width = 102.36" nominal Max Tire SLR = 21.5" Max Power Steering torque = 58,850 lb.in. Dual Steering arm required
	D-2000F	3.50	1.25	68.0	26-50	Max track at rated load = 87.00" SMC = 32.0-35.0" for 4" spring Bearing shoulder to bearing shoulder = 77.90" Overall width = 96" nominal Max Tire SLR = 21.5" Max Power Steering torque = 58,850 lb.in. Dual Steering arm required
		5.00	0.56	68.0	26-50	Max track at rated load = 85.00" SMC = 32.5-37.50" for 4" spring Bearing shoulder to bearing shoulder = 77.90" Overall width = 96" nominal Max Tire SLR = 21.5" Max Power Steering torque = 58,850 lb.in. Dual Steering arm required
22000	EFA-22T2	1.5	0	note ¹	21-45	Max Power Steering torque = 58,850 lb.in. Dual Steering arm required
	EFA-22T5	5.1	0	note ¹	21-45	Max Power Steering torque = 58,850 lb.in. Dual Steering arm required
22800	I-220W	3.74	1.50	71.0	28-43 35-50	Max track at rated load = 85.25" SMC = 32-36" for 4" spring Bearing shoulder to bearing shoulder = 80.52" Overall width = 102.36" nominal Max Tire SLR = 21.5" Max Power Steering torque = 58,850 lb.in. Dual Steering arm required
	D-2200F	3.50	1.25	68.0	26-45	Max track at rated load = 82.50" SMC = 32.0-35.0" for 4" spring Bearing shoulder to bearing shoulder = 77.90" Overall width = 96" nominal Max Tire SLR = 21.5" Max Power Steering torque = 58,850 lb.in. Dual Steering arm required
24000	EFA-24T2	1.5	0	note ¹	21-45	Max Power Steering torque = 58,850 lb.in. Dual Steering arm required
	EFA-24T5	5.1	0	note ¹	21-45	Max Power Steering torque = 58,850 lb.in. Dual Steering arm required

Note¹ – Many available, contact CVSD Applications Engineering for details

Dana Engineering Data Sheet example

ENGINEERING DATA INFORMATION

Steer Axles
D-800F
 July 2002

Beam Drop:

3.5 in. (89 mm) at spring pad and an additional 1.0 in. (25.4 mm) at center drop

Turn Angle:

40° to 50° available using a single stop screw.

Kingpin:

Diameter 1.359 in. (34.52 mm)
 Length 8.07 in. (205 mm)

Hub & Drum/Rotor Options:

- 6 stud - 8.75 in. (222.25 mm) bolt circle diameter
- 8 stud - 10.827 in. (275 mm) bolt circle diameter
- 10 stud - 11.25 in. (285.8 mm) bolt circle diameter
- ° 15 x 4 in. (381 x 102 mm) Drakes
- ° 66 mm dual piston hydraulic disc brake

Weight:

290 lbs. (132 kg)
 (Approximate, less wheel bearings, hubs, drums/rotors, and brakes)

Ground Clearance:

7.50 in. (190 mm)
 Based on a 15.5 in. (394 mm) static loaded tire radius.
 11.5 in. (292 mm)
 Based on a 19.5 in. (495 mm) static loaded tire radius.

Spring Mounting Centers:

31-35 in. (787-889 mm) for standard
 3 in. (76.2 mm) spring width.

Camber and Kingpin Angles:

North American Specification
 Camber: Left Positive 1.25°
 Right Positive 0.375°
 Kingpin Angle: Left Positive 8.875°
 Right Positive 9.125°
 (Nominal values as machined and without load applied to axle.)

Nominal Ratings:

8,000 lbs. (3,629 kg)
 On Highway

Maximum Track:

82 in. (2083 mm) at rated load

Steering Knuckles:

Forged Steel, Taper-Fit Arms

Axle Center:

Forged Steel Beam

Kingpin Intersection (K):

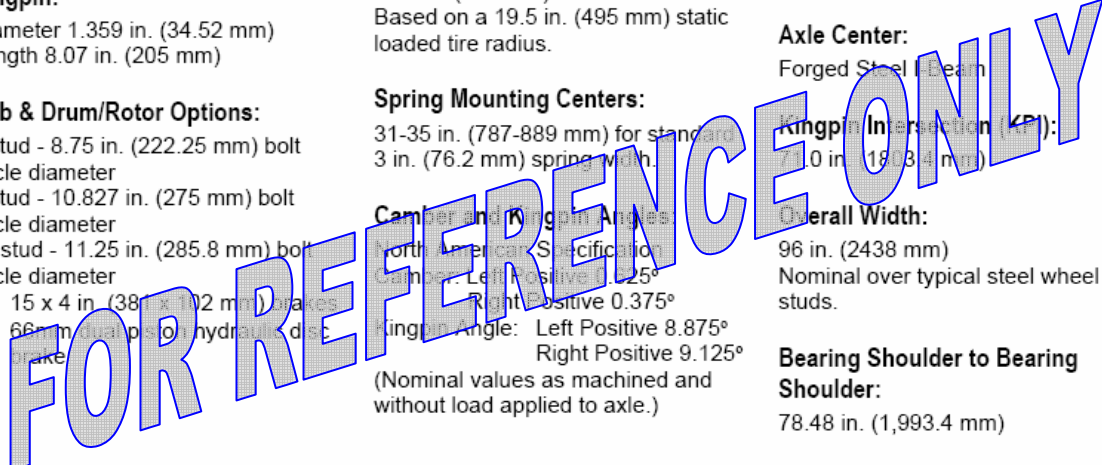
10 in. (254 mm)

Overall Width:

96 in. (2438 mm)
 Nominal over typical steel wheel studs.

Bearing Shoulder to Bearing Shoulder:

78.48 in. (1,993.4 mm)



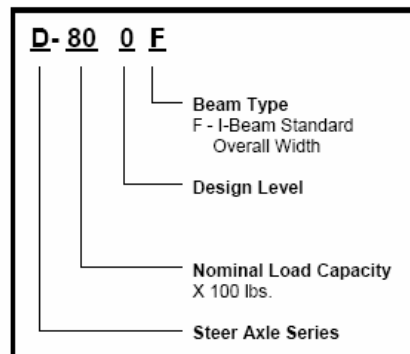
Wheel Bearings:

	Industry Number	Inside Diameter In. (mm)	Outside Diameter In. (mm)	Width In. (mm)
Outer	Cone/Cup 25877 / 25820	1.375 (34.93)	2.875 (73.02)	0.9375 (23.813)
Inner	JM207049A JM207010	2.165 (54.99)	3.770 (95.76)	1.1417 (28.999)

Steering Knuckle Options:

ABS for air drum brake flange mounting
 ABS sensor sleeve installed

Model Identification:



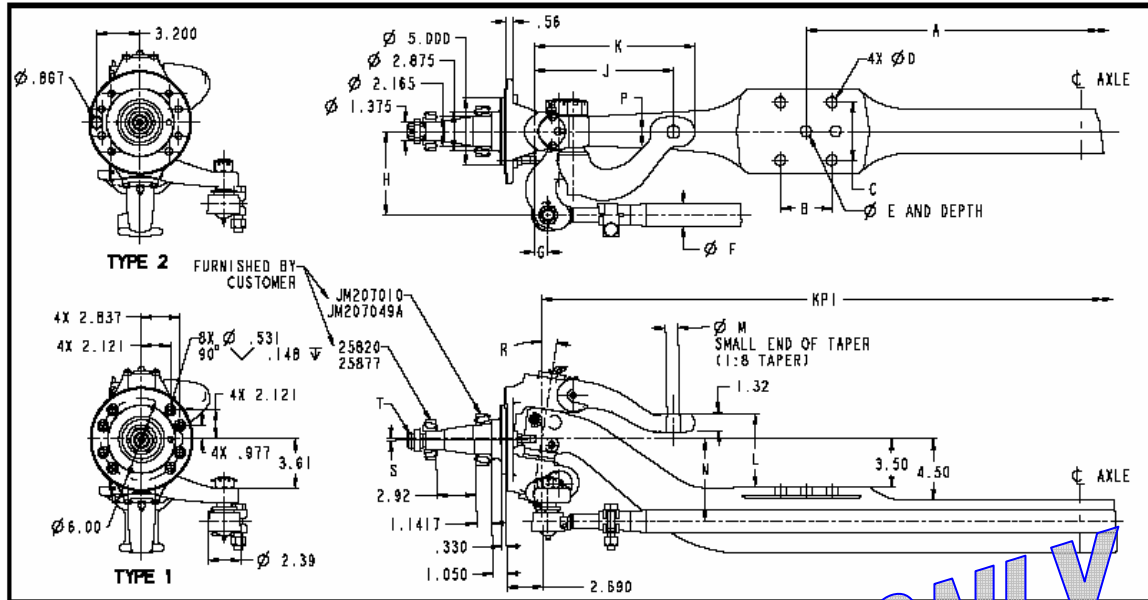
Commercial Vehicle Systems

Dana Commercial Vehicle Products Group
 3939 Technology Drive
 Maumee, Ohio, USA 43537



English Dimensions

D-800F



Steer Arms:

Arm Position	Length (J) In.	Height (L) In.	Offset (P) In.	Twist Deg.
Left	9.15-10.0	5.34	0	

Swing radius length (K) as forged = 11.72 Inch.
Swing radius length (K) can be trimmed for clearance.

Taper diameter (M) = 0.938 or 1.045 Inch standard.
Taper options (1:10) and diameter (M) as required.

Tie Rod Arms:

G	H	I	J	Arm Angle
	6.25	6.00	1.66	12.6
	6.25	6.00	1.66	17.9

Spring Pad:

Spring Centers (A) In.	Side-to-Side (B) In.	Fore-Aft C In.	Hole Diameter (D) In.	Dowel Hole (E) & Depth In.
31-35	3.81	4.25	0.812	0.812x0.62

Standard spring pad drilling shown, others as required.
Section dimensions: Width fore/aft = 6.25 In.,
Pad thickness = 0.62 In., Height = 4.88 In.

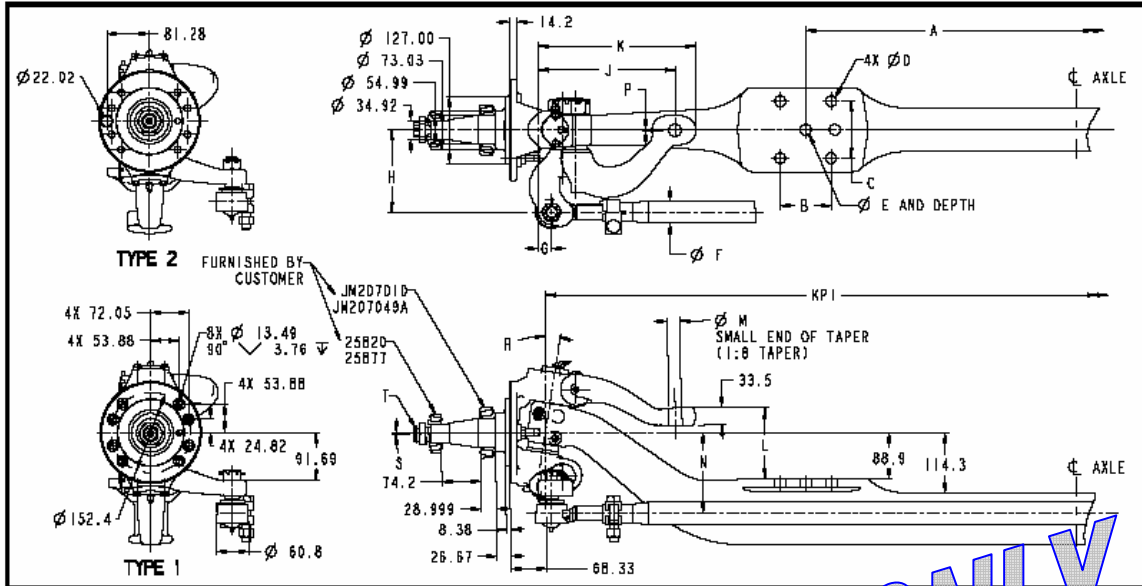
Commercial Vehicle Systems

Dana Commercial Vehicle Products Group
3939 Technology Drive
Maumee, Ohio, USA 43537



Metric Dimensions

D-800F



Steer Arms:

Arm Position	Length (J) mm	Height (L) mm	Offset (P) mm	Twist Deg.
Left	232-254	135.6	0	

Swing radius length (K) as forged = 298 mm.
Swing radius length (K) can be trimmed for clearance.

Taper diameter (M) = 23.825 or 26.543 mm standard.
Taper options (1:10) and diameter (M) as required.

Tie Rod Arms:

G	H	V	Arm Angle
158.8	152.4	42.2	12.6
158.8	152.4	42.2	17.9

Spring Pad:

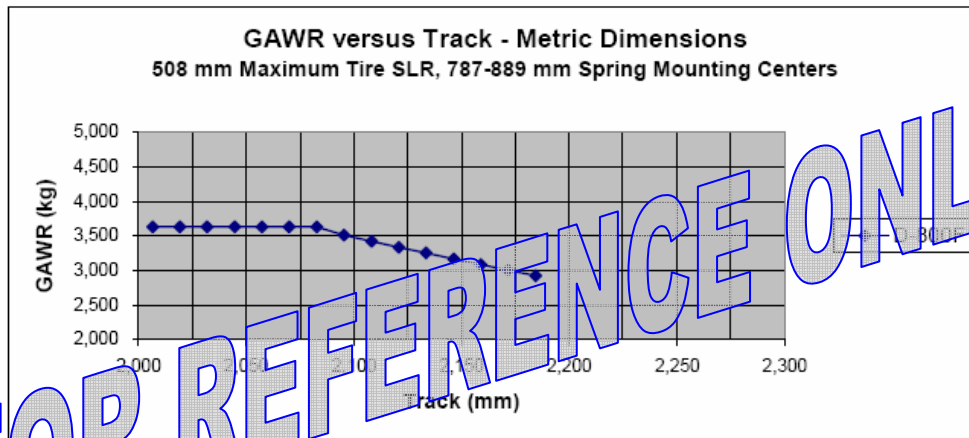
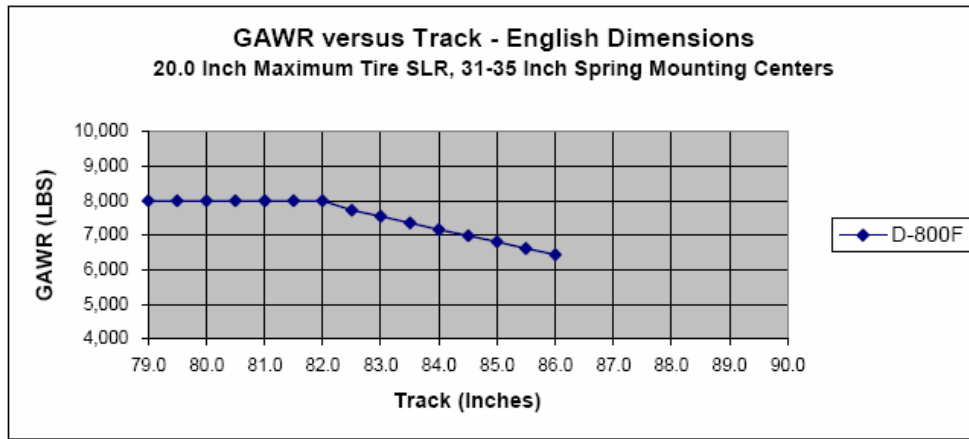
Spring Centers (A) mm	Side-to-Side (B) mm	Fore-Aft C In.	Hole Diameter (D) mm	Dowel Hole (E) & Depth mm
787-889	96.8	107.95	20.63	20.63x15.7

Standard spring pad drilling shown, others as required.
Section dimensions: Width fore/aft = 158.8 mm.,
Pad thickness = 15.7 mm., Height = 124.0 mm

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FOR REFERENCE ONLY

Camber		Camber	
per 1,000 LBS Axle Load		Left Hand	Right Hand
(LBS)	(kg)	(Degrees)	(Degrees)
4,000	1,814	0.35	0.10
5,000	2,268	0.28	0.03
6,000	2,722	0.21	-0.04
7,000	3,175	0.14	-0.11
8,000	3,629	0.07	-0.18
8,500	3,856		
9,000	4,082		
10,000	4,536		
11,000	4,990		
12,000	5,443		
13,200	5,987		
14,000	6,350		
14,600	6,622		

Toe Change	Total Toe Change	
	per 1,000 LBS Axle Load	per 454 kg Axle Load
	Values are Toe Out	Values are Toe Out
	0.0394 Inches	1.000 mm
	Based on a tire diameter of 43.5 inches.	Based on a tire diameter of 1105 mm.
	0.0518 Degrees	0.0518 Degrees

Commercial Vehicle Systems

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3939 Technology Drive
Maumee, Ohio, USA 43537



3. Alignment/Adjustment

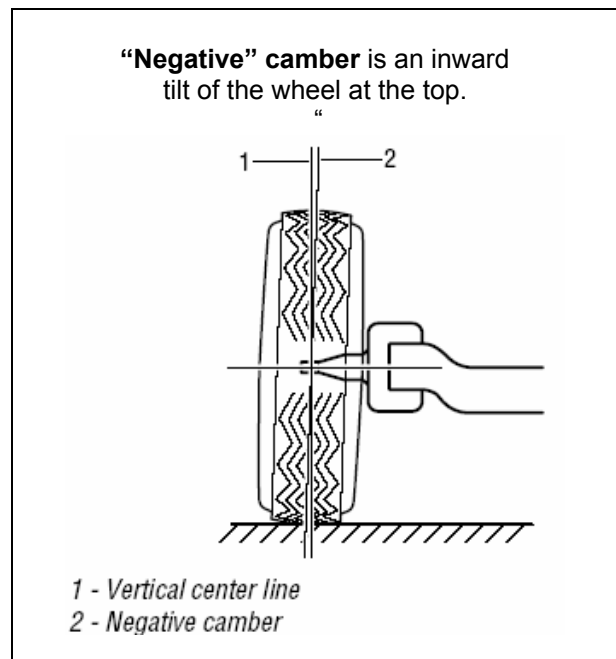
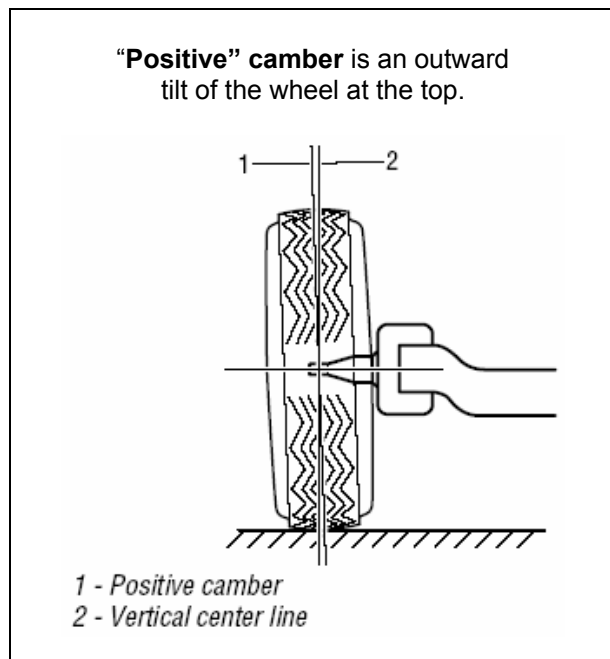
Wheel Alignment

Correct wheel alignment promotes longer tire wear and ease of handling while minimizing strain on the steering system and axle components. Use vehicle manufacturer's instructions to inspect wheel alignment.

Note: Total vehicle alignment is recommended when aligning the steer axle.

Camber

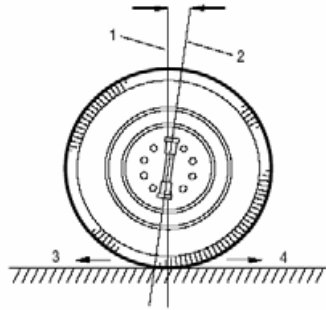
Camber is the vertical tilt of the wheel as viewed from the front of the vehicle. This is machined in at time of manufacture and is not adjustable. Most roads are made with a crown which means that the outside/right hand of the lane is lower than the left side of the lane. This improves the drainage of the road but adversely affects the vehicles handling. Road crown must be compensated for in alignment settings because a crowned road causes a vehicle to pull or drift to the lower side of the road. Typically adjustment of camber is made to have slightly more positive camber on the left to compensate for the road crown. Proper camber, in combination with correct toe and caster, assures that the tread is as flat against the road as possible under all driving conditions.



Caster Adjustment

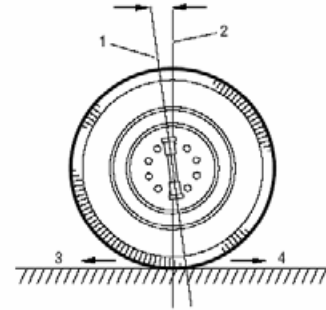
Caster is the fore and aft tilt (toward front or rear of vehicle) of the steering kingpin as viewed from the side of the vehicle. The basic purpose of caster is to maintain directional control, giving more on-center feel to the steering and return the vehicle to a straight ahead position when exiting a turn. A bicycle is a good example of caster where the front fork is almost always tilted back, giving the front wheel positive caster. On a Heavy Truck, caster is adjusted when the steer axle is mounted on the front springs. Typically a wedge shaped spacer block is used to initially set caster.

“Positive” caster is the tilt of the top of the kingpin toward the rear of the vehicle.



- 1 - Vertical center line
- 2 - Kingpin center line
- 3 - Front of truck
- 4 - Rear of truck

“Negative” caster is the tilt of the top of the kingpin toward the front of the vehicle.

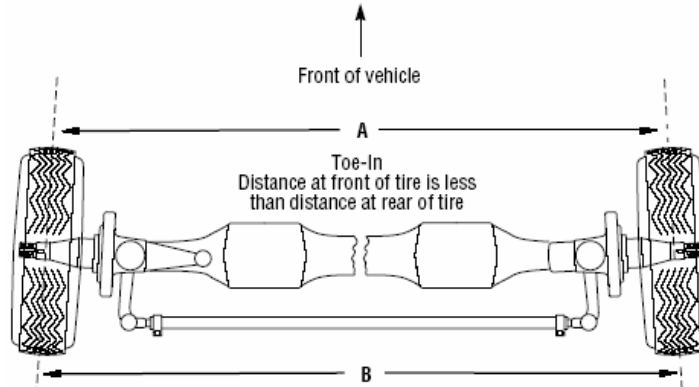


- 1 - Kingpin center line
- 2 - Vertical center line
- 3 - Front of truck
- 4 - Rear of truck

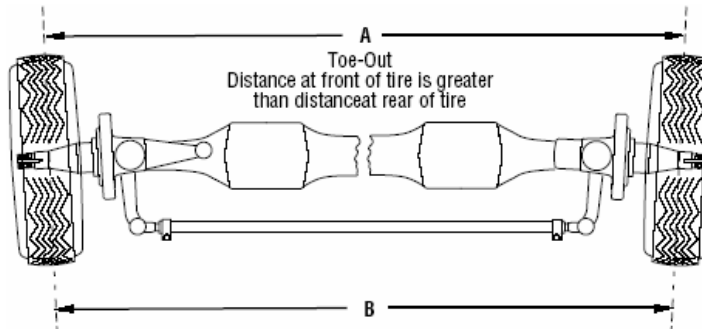
Toe Setting

Toe is the difference between tire centerline-to-centerline distances as viewed from the front of the vehicle. This is adjustable by loosening the cross tube clamps and turning the tube. Each end is threaded opposite so that when you turn one direction the tube assembly gets longer and turn the other direction and it gets shorter, moving the tires in or out depending on the adjustment needed. Cross tube clamps must be re-tightened when adjustment is completed.

Toe-in



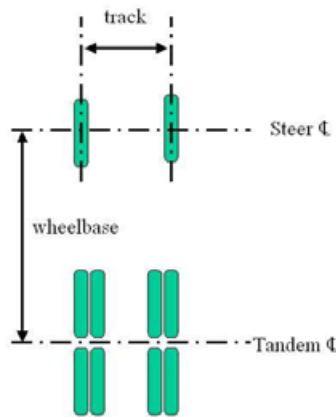
Toe-out



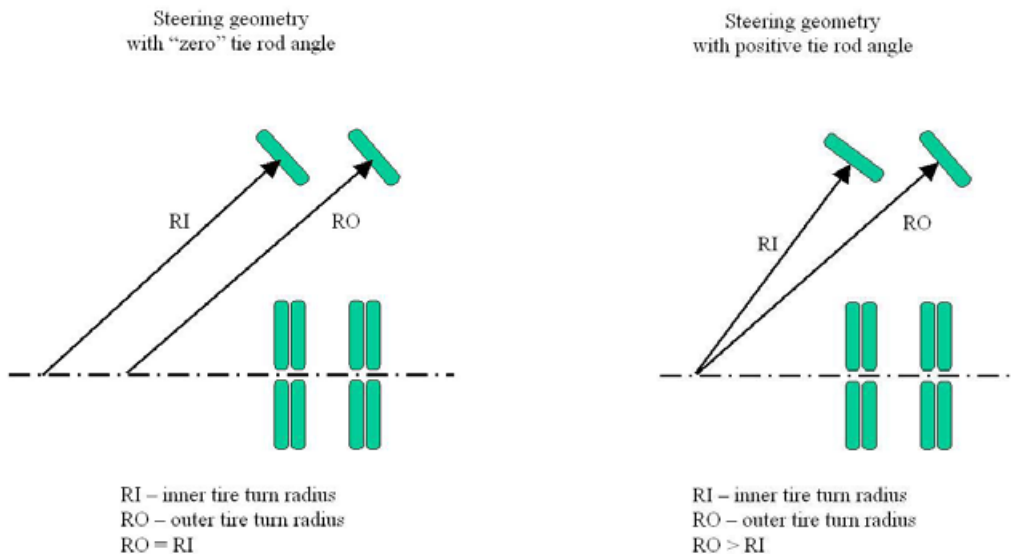
Ackermann Geometry

Ackermann Geometry is a geometric arrangement of linkages in the steering of a vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radii. When a vehicle is steered, it follows a path which is part of the circumference of its turning circle, which will have a centre point somewhere along a line extending from the axis of the fixed axle. The steered wheels must be angled so that they are both at 90 degrees to a line drawn from the circle centre through the centre of the wheel. Since the wheel on the outside of the turn will trace a larger circle than the wheel on the inside, the wheels need to be set at different angles. The Ackermann steering geometry arranges this concern by moving the steering pivot points inward so as to lie on a line drawn between the steering kingpins and the centre of the rear axle. This arrangement ensures that at any angle of steering, the centre point of all of the circles traced by all wheels will lie at a common point.

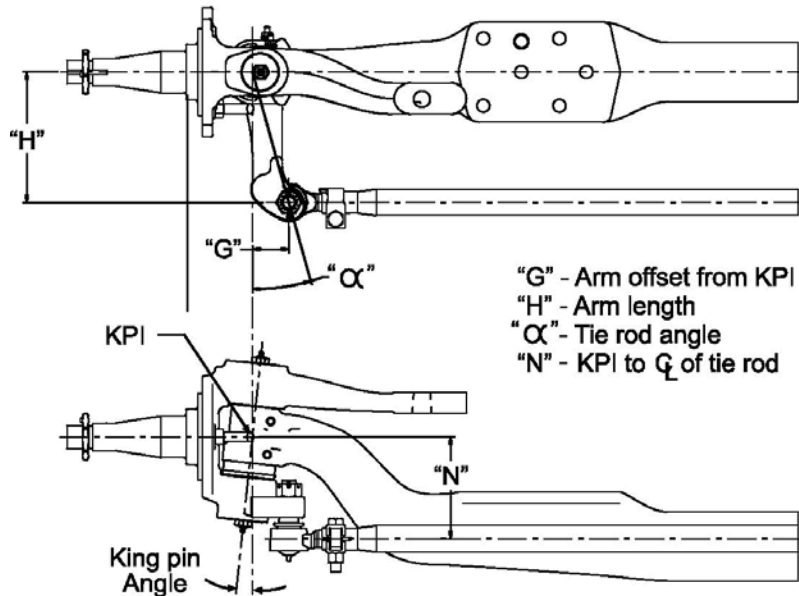
Ideally the point of intersection of the normal to the steering wheels on both sides should intersect on the line normal to the center of the drive axle. If we did not introduce a positive tie rod angle, the tires would try to drive at the same turn radius.



Wheelbase and track

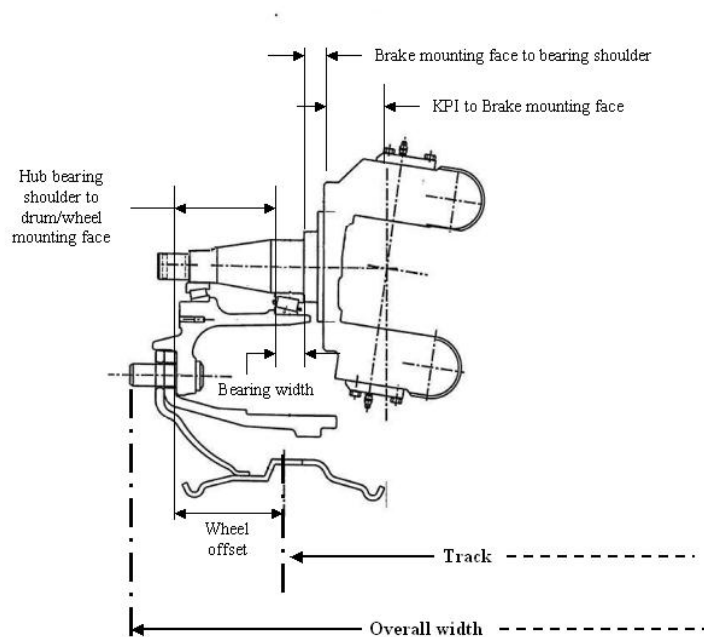


As the above, when negotiating a turn, the inside wheel needs to turn at a higher rate than the outside wheel. This is accomplished by adjusting the angle of the tie rod arm. Spicer steer axles must be set-up depending on wheelbase and track width in order to satisfy the Ackermann Geometry requirements. The dimensions "G" and "H" (from the figure below, arm offset from KPI and arm length respectively) control the *tie rod arm angle*. These dimensions are present in the Engineering Data Sheets of Spicer axle products.



Track

Track is defined as the measured distance between the centers of the tires. This is created by the combination of steer axle, hubs and tire/wheels. The picture below shows this relationship.

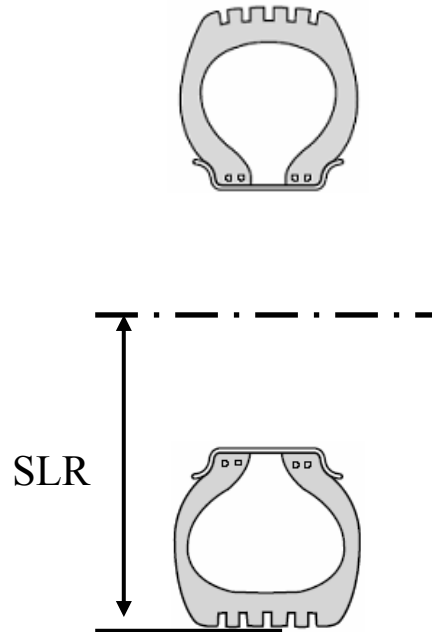


Overall Width

Overall width is defined as the dimension across the widest point on the axle. As seen in the picture above, this overall width is across the wheel studs on the hub as shown.

Tire SLR (static loaded radius)

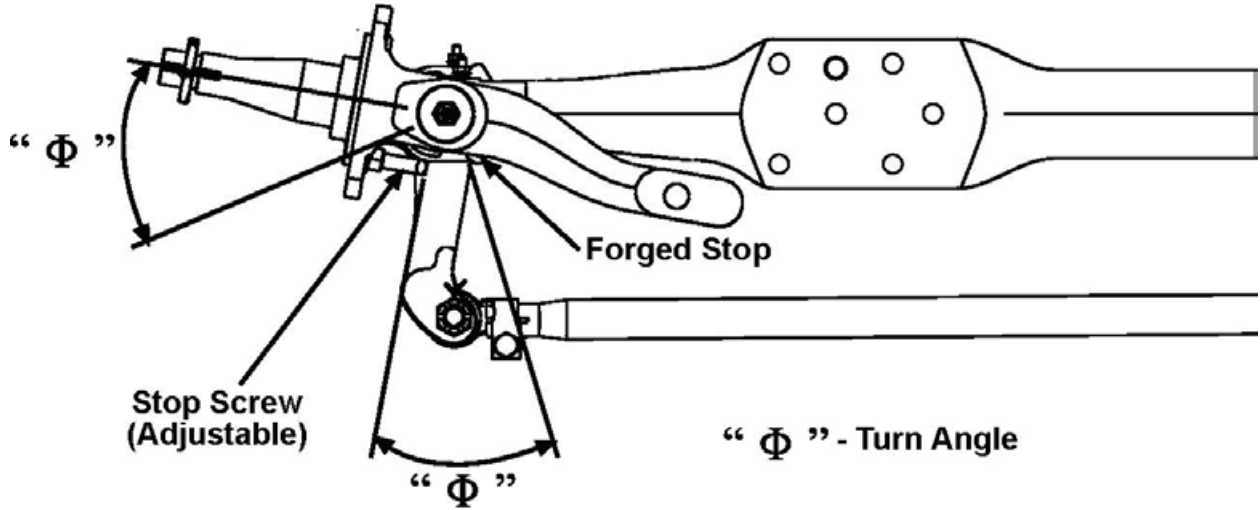
Tire SLR or *Static Loaded Radius* is the measured distance from the ground at point of contact to the center of the spindle / tire while at the recommended load. This recommended load would be the GAWR. The picture below shows the SLR for a typical situation.



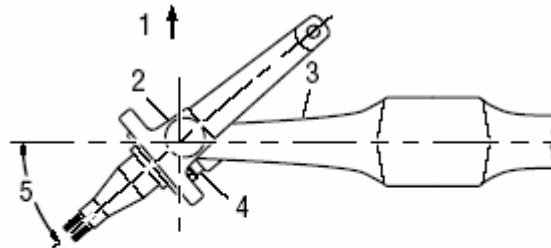
Steering Stop

Steer stops are set at the factory. Adjustment can be accomplished by loosening the jam nut and turning the stop screw in or out depending on turn angle needed. Jam nut must be re-tightened when complete. The picture below shows where this turn angle is established and the relationship between the stop screw and the forged stop on the beam. Steering stops are used to limit the amount of turn angle in a vehicle depending on clearance of the tires and steer axle components to the frame rails, suspension, etc. Most steering gears have poppet relief plungers that when properly adjusted will cut off power assist at the end of steering travel. This reduces pump wear and excessive stress on steering linkage components. They should be adjusted to cut power assist leaving a gap of 1/8 to 3/16" between the spindle stop and the axle. It is important that the steer stops are set properly first in order for the steering gear poppets to be properly adjusted to protect the power steering system. This adjustment procedure is described on the following pictures.

Steer Knuckle "Turn Angle"

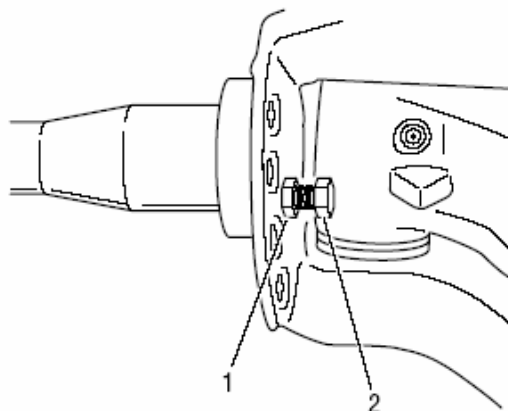


Adjustment



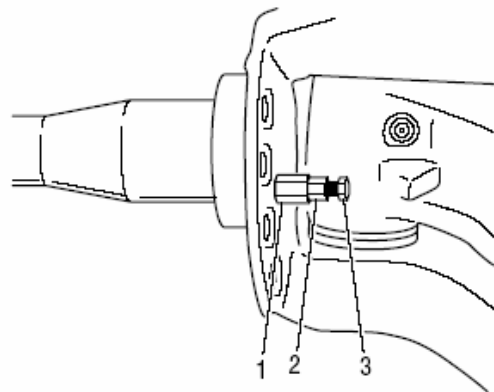
- 1 - Front of vehicle
- 2 - Steering knuckle
- 3 - Axle beam
- 4 - Steering stop adjustment (both ends of axle)
- 5 - Degree of steering angle

Option A:



- 1 - Jam nut (90-120 ft. lbs. [122-163N•m])
- 2 - Stop screw

Option B:



- 1 - Extension
- 2 - Jam nut (30-45 ft. lbs. [41-61 N•m])
- 3 - Stop screw

Lubrication

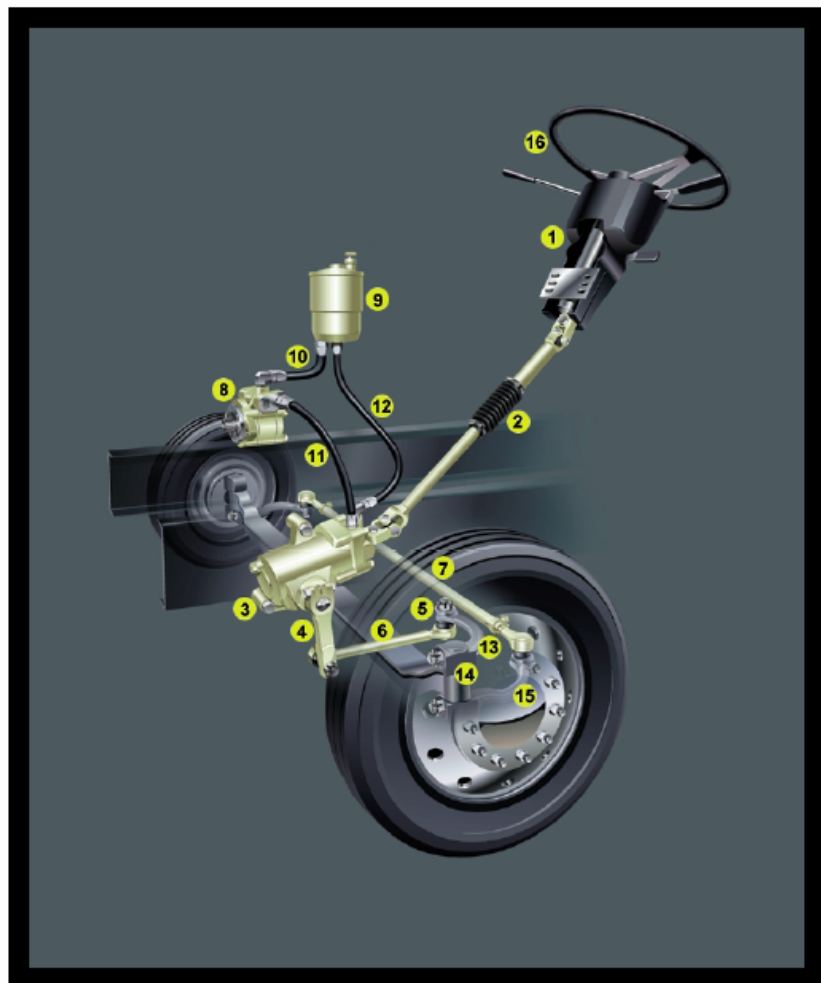
Proper lubrication practices are important in maximizing the service life of your steer axle assembly.

- **Kingpins, Thrust Bearings and Tie Rod Ends.**
- **On-Highway Applications – Standard**
Pressure lubricate every 6 months or 25,000 miles (40,000 km).
- **On-Highway Applications – LMS**
Pressure lubricate every 1 year or 100,000 miles (160,000 km). A more frequent lubrication cycle is required for axles used in on/off highway, refuse, or other severe service applications.

Steering System

The following shows a typical truck steering system from - the input from the driver through the steering wheel - to the output at the tires contacting the ground.

1. Tilt/Telescope Steering Column
2. Intermediate Column
3. Power Steering Gear
4. Pitman Arm
5. Tie Rod End
6. Drag Link
7. Tie Rod Assembly
8. Power Steering Pump
9. Reservoir
10. Suction Line
11. Supply Line
12. Return Line
13. Steering Arm
14. Steering Knuckle
15. Ackerman Arm
16. Steering Wheel



(courtesy of TRW Automotive – Commercial Steering Systems)

4. Vocation Descriptions

The following pages describe the duty cycles, and type of road usage for various vocations / situations. In addition to the guidelines set forth, any usage not described needs to be approved by the Dana Commercial Vehicle Product Group Application Engineering Department.

- City Delivery
- Construction
- Fire Service
- Heavy Haul
- Intercity Coach
- Line Haul
- Logging
- Mining
- Motorhome
- Oil Field
- Refuse
- Rescue
- School Bus
- Transit Coach

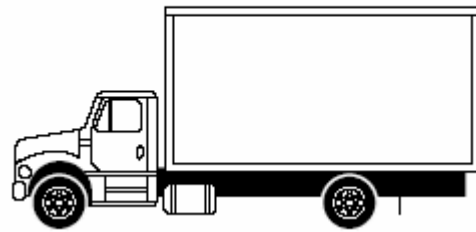
Class Definitions

Definitions for Classification of Application Operating Conditions

These definitions may vary by vocation – refer to the specific vocation in the Spicer® Drive Axle Application Guidelines.

AA	Turnpike or Interstate	Operation on limited access, well-maintained, multi-lane highways of excellent concrete or asphalt with maximum adverse grades not in excess of 3%.
A	On-Highway	Exclusive of operation on well maintained major highways of excellent concrete or asphalt construction. Terrain may be level to rolling with occasional maximum adverse grades to 8%. Operations are subject to legal weight and dimensional limitations.
B	On/Off Highway	or Mountainous Highway - Secondary roads of good concrete or asphalt where intermittent grades of up to 12% adverse may be encountered or where up to 20% of the total operating time is spent on well maintained off-highway roadways of crushed rock or similar material. Grades in this class are more frequent and severe than in Class A operation. Operation is subject to legal weight and dimensional limitations.
C	Off-Highway	Operation exceeding 20% of the time on roads of gravel or maintained crushed rock surface where the maximum grade is 12% and frequent grades of 8% can be encountered. This operation is not generally subject to legal weight or dimensional limitations.

City Delivery



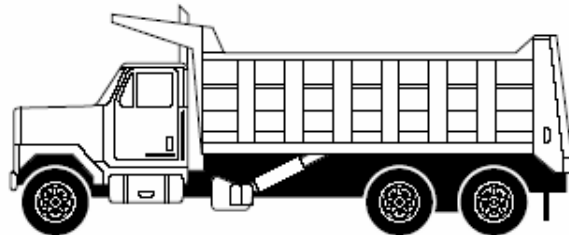
Definitions

- Pickup and delivery service within cities and/or suburban areas
- Operation on road surfaces of concrete, asphalt and maintained gravel
- Three (3) miles between starts/stops (typical)
- 100% load going /40% load return (typical)

Typical Vehicle Types

Auto Carrier	Moving Van	Refrigerated Truck
Beverage Truck	Municipal Truck	Stake Truck
Flatbed Truck	Newspaper Delivery	Tanker
Livestock Hauler	Pickup and Delivery	Wrecker

Construction



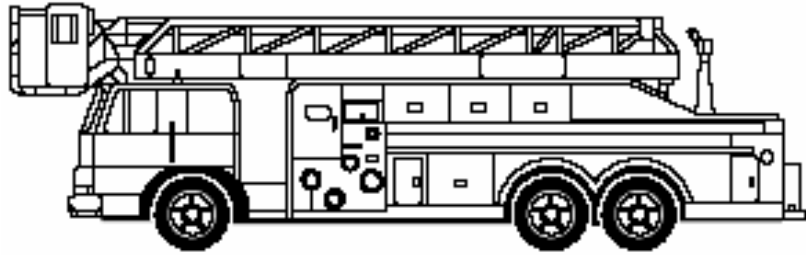
Definitions

- Movement of material to and from a job site
- 90% of loaded operation on road surfaces of concrete, asphalt, gravel, crushed rock or hard packed dirt and up to 10% of loaded operation into sandy or muddy job sites
- Maximum grades of 12%
- Assume equal load distribution from side to side

Typical Vehicle Types

Asphalt Truck	Flatbed Truck	Tank Truck
Block Truck	Landscape Truck	Utility Truck
Concrete Pumper	Mixer	
Dump Truck	Snowplow/Snowblower	

Fire Service



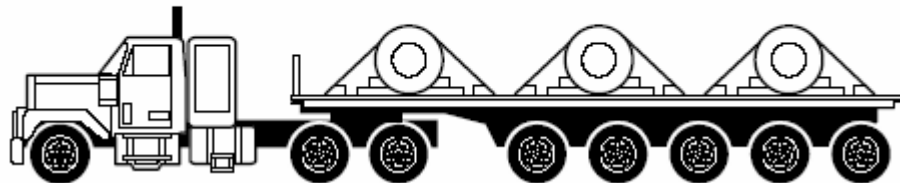
Definitions

- Vehicles used to transport people and equipment for the purpose of extinguishing fires or ambulance service
- Mileage is typically under 20,000 miles per year
- Typical vehicle routes are three (3) miles between start and stop
- Multiple high deceleration stops are common

Typical Vehicle Types

Aerial ladders	Pumpers	Tankers
Aerial platforms	Ambulance	

Heavy Haul



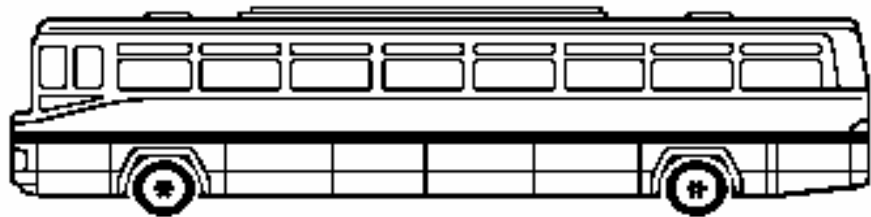
Definitions

- Movement of heavy equipment or materials at legal maximums or special permit loadings
- Operation on road surfaces of concrete, asphalt and maintained gravel
- 100% load going and empty return

Typical Vehicle Types

Equipment Hauling	Flatbed
Lowboy	Steel Hauling

Intercity Coach



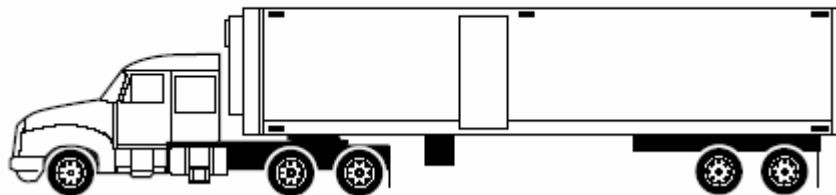
Definitions

- Transporting people and sometimes light freight between cities and/or suburban areas
- Operation on road surfaces of concrete, asphalt, maintained gravel, crushed rock, or hard packed dirt
- High mileage operation
- Typical vehicle routes exceed 30 miles between start and stop
- No towed load allowed

Typical Vehicle Types

Tour Coach
Cross Country Coach

Line Haul



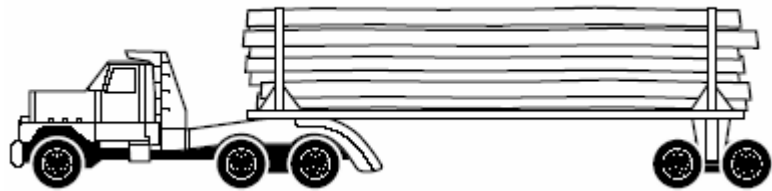
Definitions

- Linehaul is moving different types of freight in high mileage operation (over 60,000 miles/year)
- Operation on road surfaces of good to excellent concrete or asphalt
- Distances are more than 30 miles between starting and stopping
- Typical vehicle configurations are 4X2, 6X2 and 6X4 tractor/trailer combinations and straight trucks

Typical Vehicle Types

Auto Hauler	Refrigerated Freight	Bulk Hauler
Livestock Hauler	Doubles	Moving Van
Flatbed Trailer	Pipe Hauler	General Freight
Tanker	Grain Hauler	Triples

Logging



Definitions

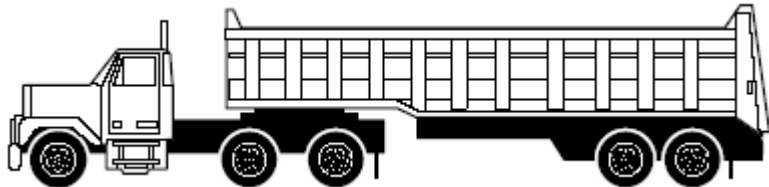
- Movement of logs, chips and pulp between logging sites and/or mill
- 3 to 30 miles between starts and stops (typical)
- 90% of loaded operation on road surfaces of concrete, asphalt, maintained gravel, crushed rock or hard packed dirt and up to 10% of loaded operation into sandy or muddy job sites
- 100% load going and empty return

Typical Vehicles Types

Chip Hauler
Log Hauler

Straight Truck With Trailer
Tractors with Pole Trailers

Mining



Definitions

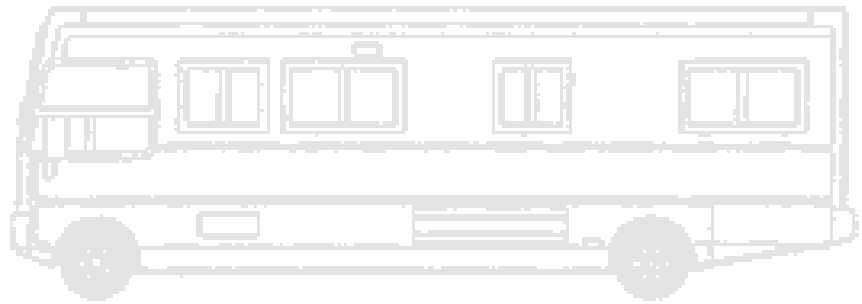
- Movement of rock, ore, gravel and minerals between mine sites and delivery sites
- 3 to 30 miles between starts and stops (typical)
- 90% operation On-Highway and up to 10% into sandy or muddy job site
- 100% load going and empty return

Typical Vehicle Types

Bottom Dump Trailer
Semi-End Dump

Transfer Dump
Hopper Trailer Combinations

Motorhome



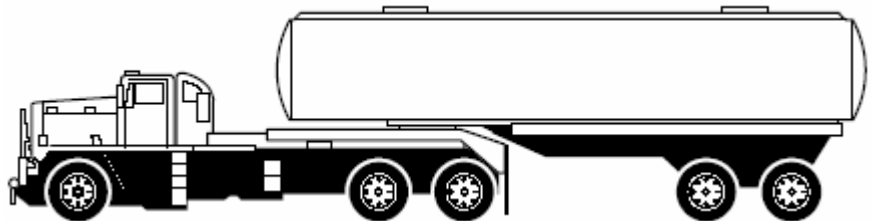
Definitions

- Vehicles generally used for non-commercial transportation and as traveling domiciles for families
- May pull small passenger car, SUV or pick-up
- Typical vehicle routes exceed 30 miles between start and stop
- Annual mileage will be under 30,000
- Typical operation is on paved roads and short distances within campgrounds and parks

Typical Vehicle Types

Recreational Vehicles

Oil Field



Definitions

- Movement of production related products, supplies and tools between job sites
- Movement of processing equipment and laboratories on job sites
- Low mileage operation on road surfaces made of concrete, asphalt, maintained gravel, crushed rock or hard packed dirt
- Maximum grades of 12%

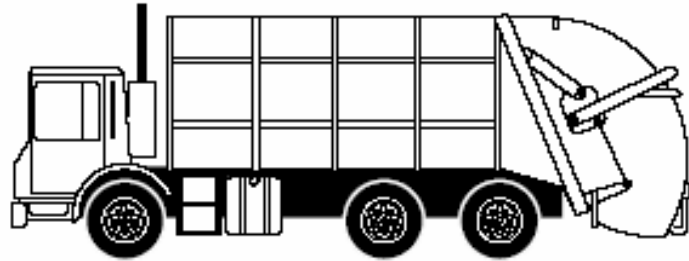
Typical Vehicle Types

Cementing Vehicle
Demolition
Tanker

Geophysical Exploration
Rigging Truck
Fracturing Truck

Drill Rig
Winch Truck

Refuse



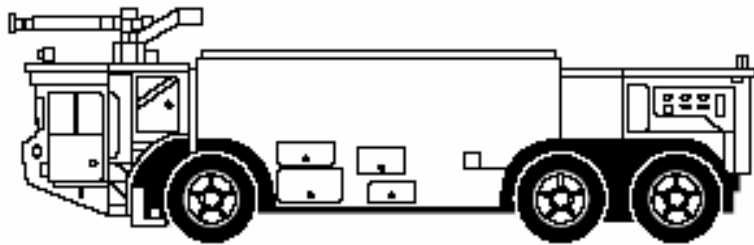
Definitions

- Vehicles used for residential refuse/recycle pickup, on adverse **grades** up to 20%, typically a high number of stops per mile
- Or, vehicles operated in commercial/industrial pickup, on adverse **grades** up to 20%, typically a low number of stops per mile
- Or, vehicles used in transfer/relocation on maximum **grades** of 8%, typically greater than 10 mile trips
- 90% of loaded operation on road surfaces of concrete, asphalt or maintained gravel and up to 10% of loaded operation into landfill, transfer or recycling sites

Typical Vehicle Types

Front/Rear/Side Loader	Sewer/Septic/Vacuum	Roll-Off
Liquid Waste Hauler	Scrap Truck	Transfer Vehicle
Residential/Commercial Pickup		Street Sweeper

Rescue



Definitions

- Specialized vehicles for rapid acceleration to crash sites away from hydrant hookups
- Operation on road surfaces made of concrete, asphalt, maintained gravel, crushed rock, hard packed dirt, or other similar surfaces for 90% of the time and into sandy or muddy crash sites for 10% of the time
- Low mileage operation

Typical Vehicle Types

Airport Rescue Fire (ARF)	Crash Fire Rescue (CRF)
Rapid Intervention Vehicle (RIV)	Emergency Service

5. Application Approval Procedure

Automatic Submission - Application Approval Database

In addition, requests can be submitted using the Dana Commercial Vehicle Systems Applications Approval Database found at the following site:

www.cvsengineering.com/dana

Applicants must have a user ID and password from Dana Application Engineering Department prior to use.

Application Approval Database Instructions

Step by step instructions for filling out the necessary fields in the Dana applications database can be obtained from the Dana website at www.Dana.com/CommercialVehicle.

Questions

For answers to questions concerning these Guidelines or to request an Application Approval Request Form for a use not covered by these Guidelines, contact:

Dana Commercial Vehicle Products Group
3939 Technology Drive
Maumee, Ohio, USA 43537
Phone: (877) 777-5360

6. Glossary of Terms

- ABS** – Antilock Brake System; ABS electronically monitors wheel speed and prevents wheel lock-up by rapidly cycling the brakes during panic stops and when stopping on low-friction surfaces.
- Ackermann geometry** – the relative angular movements of the front wheels while traveling along a curved path; a double pivoting steering system where the outer tie rod arms are bent slightly inward so that when a vehicle is making a turn, the wheels toe-out and the inside wheel will turn more sharply than the outer wheel; this is done to compensate for the greater distance the outside wheel must travel; these angular movements relate to the length of wheelbase and the width of track; true Ackermann geometry includes the Jeantaud modification to Rudolph Ackermann's original principle.
- Alignment** – method of maintaining proper relationship between all components of the steering system.
- Beam drop** – distance from the kingpin to spindle intersection and the spring mounting pad surface.
- Bearing shoulder to bearing shoulder dimension** – distance from the machined inner bearing contact point on one side of the axle to the other machined inner bearing contact point on the other side.
- Belleville washer** – also known as coned-disc springs or Belleville disc springs; provide very high loads at small deflection and also maintain a constant force regardless of dimensional variations due to wear, temperature changes or tolerances.
- Bridge formula** – formula used to determine maximum gross weight permissible on any group of axles.
- Broached bushing** – bushing that is finished by a round cutting tool that has multiple teeth each removing a small portion of the bushing material to achieve desired finished size.
- Camber** – the tilt of the wheel side to side while looking from the front; places the road contact point closer to the king pin axis thereby reducing road inputs to the steering system and contributes to steering stability.
- Camber, negative** – top of the wheel tilts inward.
- Camber, positive** – top of the wheel tilts outward.
- Caster** – tilt of the kingpin centerline looking from the side; offers directional stability and assists in returning wheels to a straight ahead position through self centering action.
- Caster, Negative** – kingpin centerline projected behind the road contact point.
- Caster, Positive** – kingpin centerline projected ahead of the road contact point.
- Compressible inserts** – foam inserts installed in the top and bottom of the kingpin under the cap that reduce the pressure/vacuum that is found in the bushing area during typical service.
- Cramp angle** – maximum turn of steering wheel in either direction.
- Creep rating** – load rating for a vehicle used at a regulated low speed while maneuvering or driving with lift able axles in retracted mode.
- Cross link** – composed of the adjustable cross tube and threaded tie rod ends with ball sockets that connect the LH knuckle tie rod arm to the RH knuckle tie rod arm.
- Cross tube** – center tube portion of a cross link assembly that is threaded with opposite threads on each end thereby allowing adjustment by turning the tube with one hand.
- CTI** – Central Tire Inflation; means of easily adjust the vehicle tire pressure, both inflate and deflate, for the conditions encountered whereby improving vehicle mobility performance.
- Double drop** – beam having a drop in the center between the spring mounting pads as well as the drop from the KPI to the spring mounting pads.
- Draglink** – connection between the pitman arm and the steer ball on the steer arm; acts as a pull-and-push rod to convey steering movements from the chassis-mounted steering box to the spring-mounted axle.
- Draw key** – fastener that works like a wedge and provides a mechanism to lock the beam to the kingpin while allowing rotation of the knuckle on the kingpin.
- Drop socket** – socket with the ball center not coincident with the threaded end.
- Dry park maneuver** – turning steering wheel/tires without any forward or reverse movement.
- Dual draw key** – arrangement of two draw keys used to balance load on kingpin maintain alignment of kingpin to knuckle/beam bore.
- Foam insert** – foam piece also know as the compressible insert.
- GAWR** – Gross Axle Weight Rating; is the total weight capacity of the axle.
- GCWR** – Gross Combination Weight Rating; is the total weight capacity of a combination vehicle, (tractor and trailer) as determined by axle ratings; it includes the weight of the vehicle and payload.
- Grade** – the degree of inclination of a road.
- I-Beam** – forged steel structural beam constructed in the shape of an “I”.
- IASS** – InterAxle Speed Sensor.

Integral knuckle – one piece steel knuckle forging made with both steer and tie rod arms forged into one piece.

Jam Nut – second nut on a screw or bolt which locks against the first nut (i.e., jams against it so that the nut won't come loose).

Kingpin – front axle pin allowing wheels to steer vehicle.

Kingpin angle – angle of the kingpin in relation to a vertical line at the point of intersection on the ground at tire contact as viewed from the front or back.

Knuckle – integral with the spindle, the inner portion of which is affixed to and pivots on the kingpin.

Knuckle cap – bolt on or threaded in cap used to seal the outer sides of the upper and lower portion of the steer knuckle; this cap is used to prevent contamination from getting into the kingpin joint area.

Knuckle seal – seal built into inner side of the upper and lower portion of the steer knuckle; this seal is used to prevent contamination from entering the areas between the kingpin, the knuckle and the beam.

KPI – KingPin Index.

Lift able axle – axle that is capable of lifting off the ground and reducing load during parking maneuvers and lowering to the ground and reducing the load for bridge laws.

Limited access – roads where access is controlled and limited to entrance and exit in designated areas such as highway ramps; see also Turnpike.

Line Haul – trucking involving moving different types of freight in high mileage operation (over 60,000 miles/year).

LMS – Low Maintenance System that eliminates wheel-bearing adjustment and increases service intervals using a combination of lube, bearings and seals.

Locator dowel hole – drilled hole located centrally on the spring pad drilling that is used to locate the caster block used to attach the springs to the steer axle.

OAW – OverAll Width across the widest portion of the vehicle/axle/etc.

OEM – Original Equipment Manufacturer.

Off Highway – operation exceeding 10% of the time on unimproved surfaces such as loose dirt, mud and sand.

On Highway – refers to trucking performed on turnpike quality roads, freeway or expressway.

On/Off Highway – refers to trucking operations that involve traveling both on highway and on roads of lesser standards, for example timber hauled out of the woods on forest roads and then on the highway to the mill.

Pitman arm – arm attached between the steering gear sector shaft and the drag link which transmits the steering force from the cross shaft to the steering linkage system; this is how the rotary motion of the steering wheel is turned into lateral movement of the arm.

Pusher axle – a "dead axle" (no driving capability) used to give vehicle more weight carrying capacity; a pusher axle is ahead of the drive axle; a tag axle is behind the drive axle; this type of axle may have the capability of being raised or lowered and some are made to be "steerable".

Regional Haul – on-highway usage within a region, typically a one day round trip.

Relief pressure – maximum pressure where the steering gear is protected from providing too much load into the steering system.

Rolling radius – distance from center of the tire to the ground under rated axle capacity.

Secondary – roads that are typically well maintained gravel or crushed rock, surface conditions are not as favorable as on primary roads.

Sensor sleeve – rigid steel sleeve mounted in the knuckle to provide a pilot for the ABS sensor to be mounted in close proximity to the tone ring on the hub.

Shims – spacers used to fill in the space between knuckle and top of beam after thrust washer is installed on the bottom side of the beam.

SLR – Static Loaded Radius; distance, expressed in inches, from the center of a tire/wheel assembly to the pavement, measured when mounted on a vehicle and loaded to its maximum rated capacity.

SMC – Spring Mounting Center; distance between frame rails where beam is mounted in the vehicle.

Spring pad – flat locator surface on the beam is drilled for the specific mounting pattern for the U-bolt connect to the leaf spring.

Steer arm – rigid connection between the steering mechanism and the steer knuckle.

Steer arm swing radius – radius created when the steer knuckle rotates from stop to stop; establishes clearance window.

Steering gear – the mechanism that translates the steering wheel rotation into movement at the steer knuckle through the draglink.

Steering knuckle – the inner portion of the spindle that is connected to and pivots on the kingpin allowing the wheels to turn while under load.

Stop screw – a combination screw and lock nut arrangement that limits the angular travel of the steer knuckle in a steer axle.

Tag axle – a "dead axle" (no driving capability) used to give vehicle more weight carrying capacity. A tag axle is behind the drive axle. This type of axle may have the capability of being raised or lowered and some are made to be "steerable".

Taper – cone shaped object or form.

Thrust bearing – these bearings are designed to carry only thrust loads.

Tie rod arm – the arm that is rigidly connected to the steer knuckle that ties the LH knuckle to the RH knuckle and also sets up the steering/Ackermann geometry.

Tie rod arm angle – the angle formed in the horizontal plane between the vertical plane formed by the kingpin intersection/pivot point and the tie rod arm mounting hole where the tie rod end attaches.

Tie rod end – threaded part with a ball socket for articulation which attaches in the cross tube for adjustment; each end is threaded the opposite of the other.

Tie rod offset – the distance from the kingpin intersection/pivot point to the tie rod arm mounting hole where the tie rod end attaches in the lateral direction.

Tire pressure controls – see CTIS.

Toe – the difference between the tire centerline-to-centerline distances in the front versus the rear.

Toe-in – positive toe; tires are pointing in as seen from the front; provides straight-line directional stability.

Toe-out – negative toe; tires are pointing out as seen from the front; will result in "road wander".

Track – distance between the centers of the tires.

Tubular beam – beam constructed of a seamless / hollow tube with forged steel beam ends welded on the ends to create the foundation of a steer axle.

Turnpike – expressway or freeway.

Unitized hub system – hub system that is factory filled with synthetic grease and sealed to avoid lubrication intervals, bearing adjustment, and seal replacement, eliminating hours of typical maintenance.

Wheelbase – distance between centerline of front to rear axles or to centerline of tandem axle.

Wide track – axle that is wider than standard maximum 96" overall width.

Woodruff key – a half-moon shaped piece of metal used to secure something to a shaft which has a notch cut in the shaft to accommodate the key.

Zerk – grease fittings; lubrication fitting used for pressurized grease application

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