Form 995T-2 09/05
Supersedes 995T-2 03/05

WinAlign® HD

Wheel Alignment Education Guide for Heavy-Duty Trucks

HUNTER Engineering Company

What is Proper Wheel Alignment?

A properly aligned vehicle is one in which all wheels are aimed in the same direction. Some very low tolerance or acceptable error is designed into each vehicle by the manufacturer (see the vehicle manufacturer specifications).

How Can Wheel Alignment Benefit Your Operation?

The number one and number two operating expenses in over-the-road transportation are fuel and tires respectively. Both are typically perceived as hard to control. Routine wheel alignment is the most effective way to control tire costs and can impact fuel costs as well.

Problems created by misalignment:

- ***Excessive tire wear***
- ***Increased fuel consumption caused by increased rolling resistance***
- ***Unsafe vehicle handling characteristics***
- ***Driver fatigue and driver retention***
- ***Premature suspension component wear***

Between 70 and 80 percent of heavy duty vehicles on the road today are misaligned!

The transportation industry, as a whole, finds that outsourcing timely, accurate alignment service performed by qualified technicians is difficult to manage. As a result alignment is mostly addressed after the damage has been done. Simply making alignment part of a vehicle or fleet preventive maintenance program allows operators to easily get a handle on this perceived uncontrollable expense.

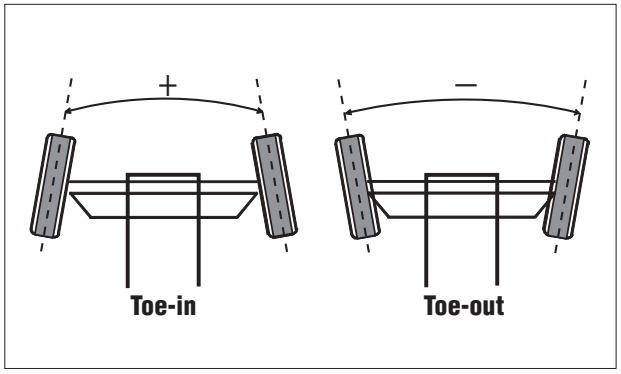
Hunter recommends a minimum of two to three alignments per year or every 50,000 to 60,000 miles as part of the average vehicle's preventive maintenance program.

Alignment service is a natural fit for service facilities currently repairing suspensions. Technicians performing repairs on heavy duty suspensions are in effect alignment technicians. The only required equipment is the precision measuring system.

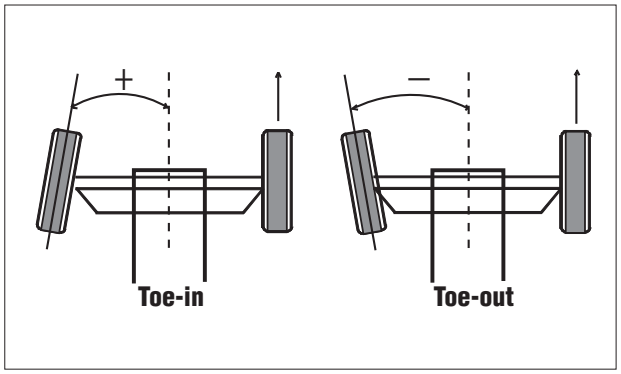
Alignment Angles and Effects

Tire Wear Due to Improper Toe Settings

Toe is the most critical alignment setting for steer axle tire wear. It is measured in inches, millimeters or degrees.

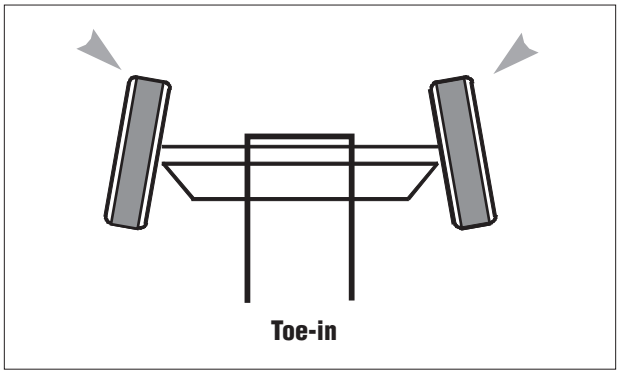


Total Toe is the angle formed by two horizontal lines through the planes of two wheels. Toe-in is when the horizontal lines intersect in front of the vehicle; Toe-out is when the horizontal lines intersect behind the wheels.

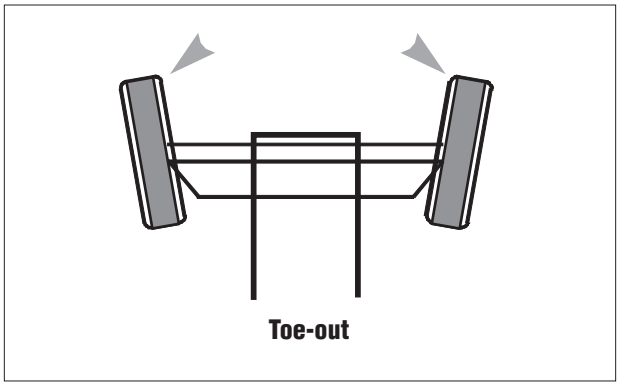


Individual Toe is the angle drawn by a line drawn through a plane of one wheel referenced to the thrust line of the vehicle. Toe-in is when the horizontal lines intersect in front of the wheel. Toe-out is when the lines intersect behind the wheel.

Results of excessive toe is wear on the leading edge of the tire.

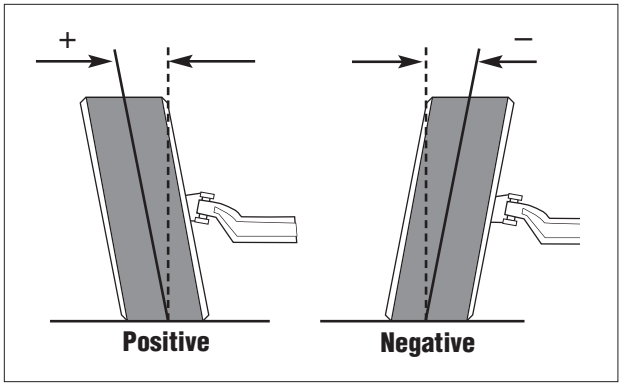


Excessive toe-in wears the outside of the tire.

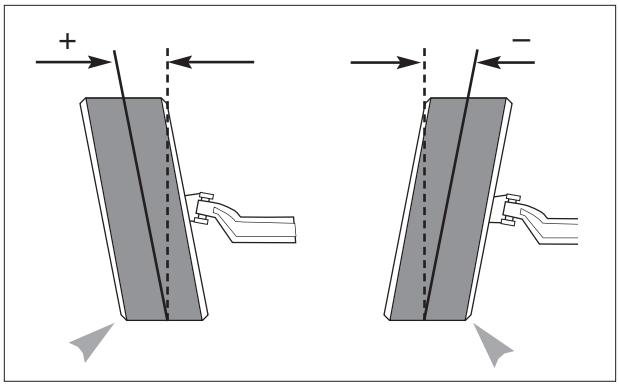


Excessive toe-out wears the inside of the tire.

Tire Wear Due to Improper Camber Settings

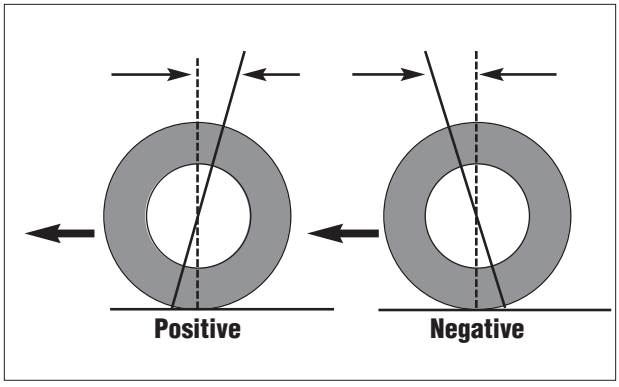


Camber is the angle formed by the inward or outward tilt of the wheel referenced to a vertical line. This angle is measured in degrees. Camber is positive when the wheel is tilted outward at the top and is negative when the wheel is tilted inward at the top.



Tire wear from excessive camber: Wear from positive camber is on the outside shoulder of the tire; with negative camber, wear is on the inside shoulder.

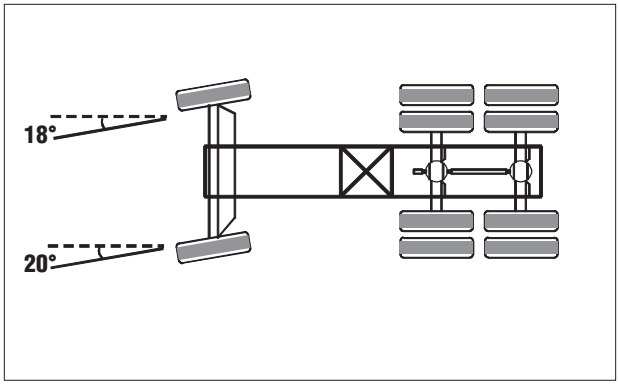
Caster: A Factor in Vehicle Handling



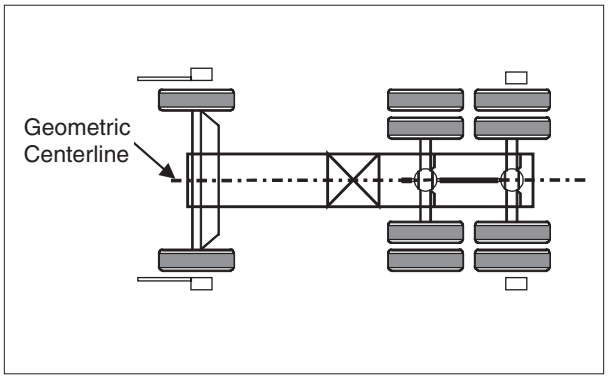
Caster is the forward or rearward tilt of the steering axis in reference to a vertical line. The angle is measured in degrees. Caster is positive when the top of the steering axis is tilted rearward and is negative when the tilt is forward. Caster is usually a factor in vehicle handling, but can affect tire wear. Proper caster is important for directional stability and returnability. Improper caster can cause shimmy, excessive steering effort, pulling and shoulder wear on the steer tires.

Turning Angle

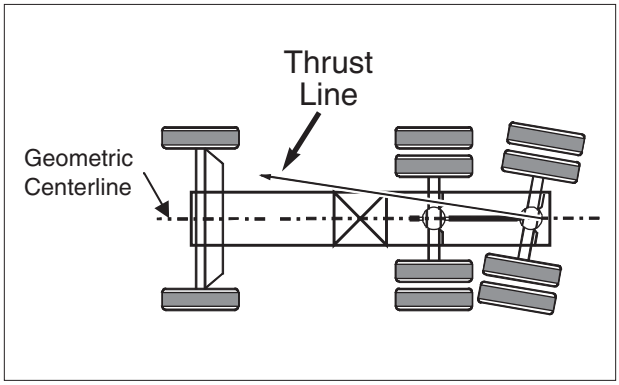
Turning angle is the difference in the angles of the front wheels in a turn. This measurement is an aid in diagnosing steering problems and irregular tire wear. Improper turning angle may cause scuffing, leading to excessive tire wear.



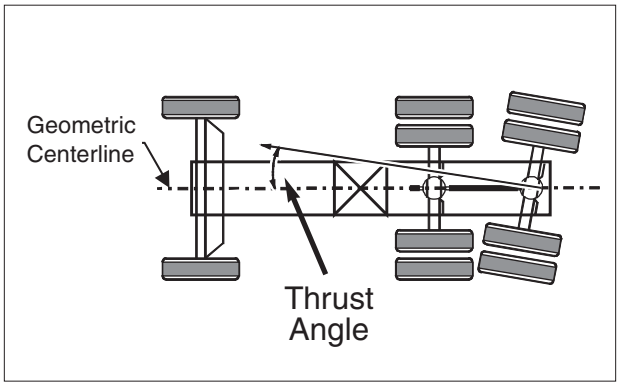
Tandem Axle Angles



Geometric centerline of a vehicle is a line drawn through the midpoints of the front axle and the rear reference axle.



Thrust line is the bisector of the total toe angle of an axle. It represents the direction the axle "points" compared to the centerline of the vehicle.

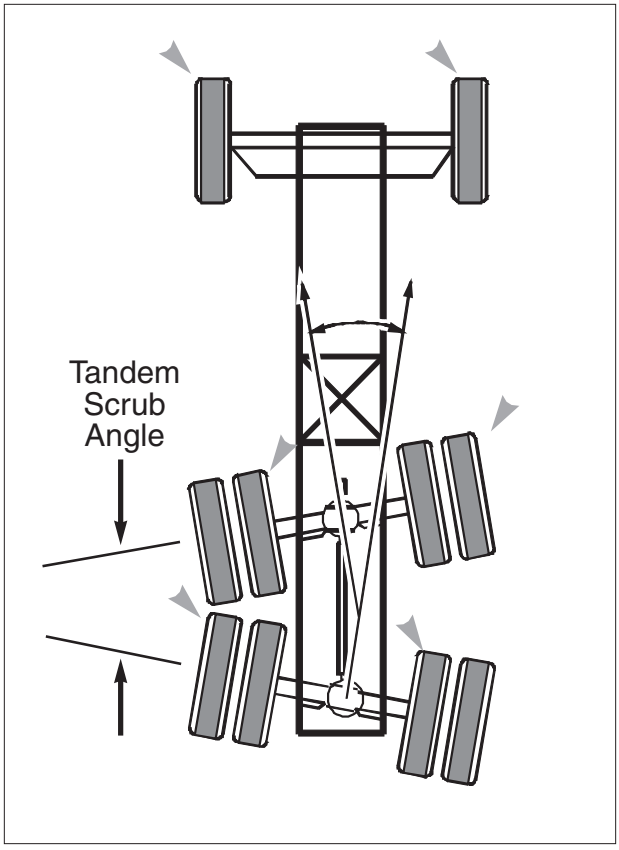


Thrust angle is the angle formed by the geometric centerline and the thrust line of an axle.

Tandem scrub angle is the angle formed by the two thrust lines of a tandem axle vehicle.

In the diagram below, misalignment causes the tandem axles to work against each other.

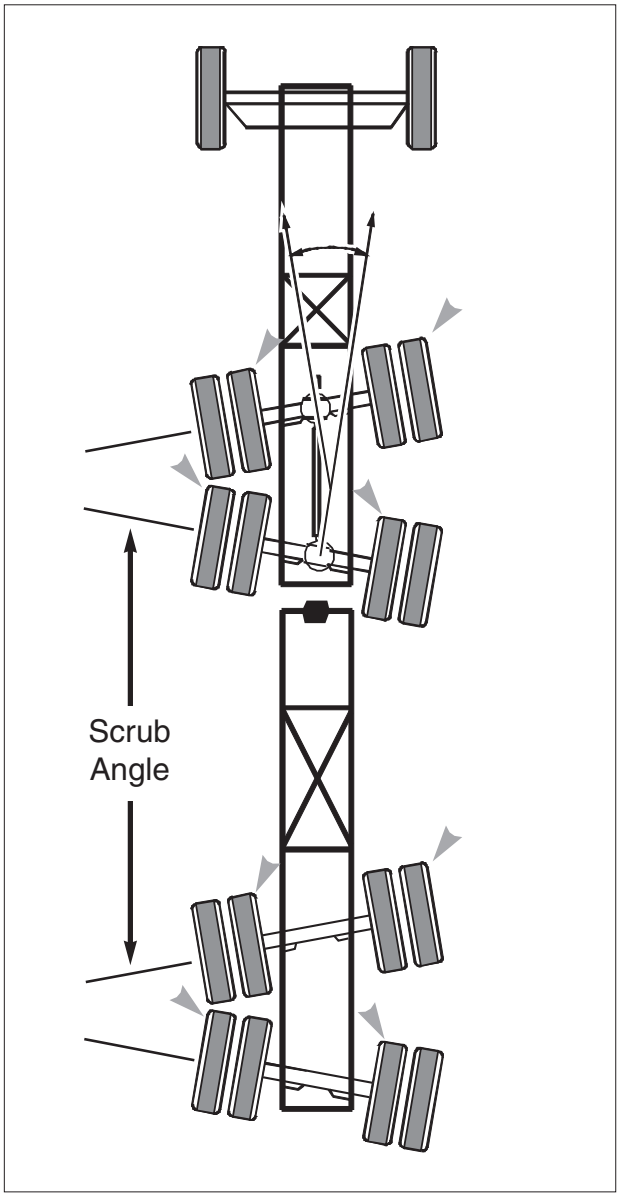
The steer axle must be turned to offset the "push" of the axles and keep the vehicle moving straight ahead. This causes <u>every</u> tire on the vehicle to scrub.



Tire wear from tandem scrub occurs at the leading edge of the steer tires, in a pattern called "inside/outside" wear. For example, on the front axle of this vehicle, wear would occur on the outside of the left steer tire and on the inside of the right steer tire. Tire wear would occur on <u>all</u> drive axle tires.

Trailer Alignment and Tire Wear

The same conditions that cause tandem scrub on tractors also apply to tractor-trailer combinations.



Misaligned trailer axles cause tandem scrub, resulting in rapid wear on all tires.

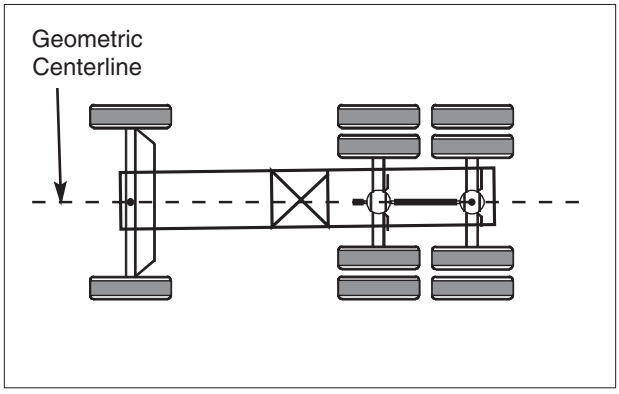
If the trailer doesn't track correctly, it exposes more area to wind resistance. This can affect handling and fuel economy.

Alignment Angles Affect Rolling Resistance and Fuel Consumption

While the effects of misalignment show clearly in tire wear, the effects on fuel consumption are less easy to quantify. Fuel consumption is affected by many factors.

However, it is obvious that misalignment must increase rolling resistance – and rolling resistance is a major cause of fuel consumption.

Geometric Centerline Alignment

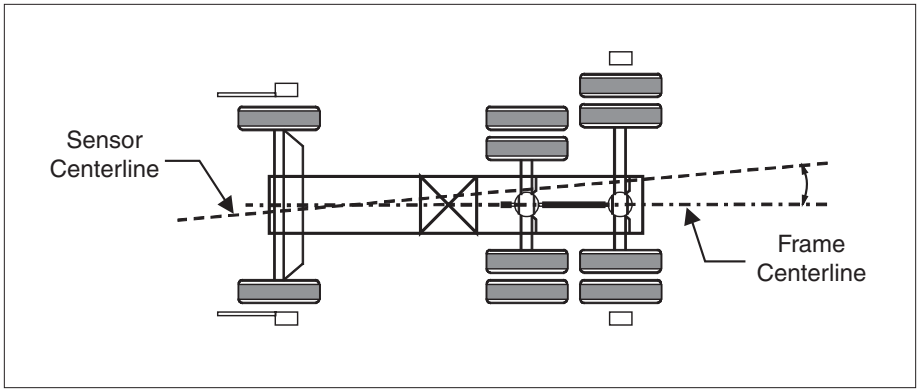


Geometric Centerline Alignment can be used as a reference from which to compute individual toe angles. The Geometric Centerline of a vehicle is established by placing a line from the midpoint of the front axle and the midpoint of the rear-most axle.

The Geometric Centerline is not based on frame rails or cross member reference points.

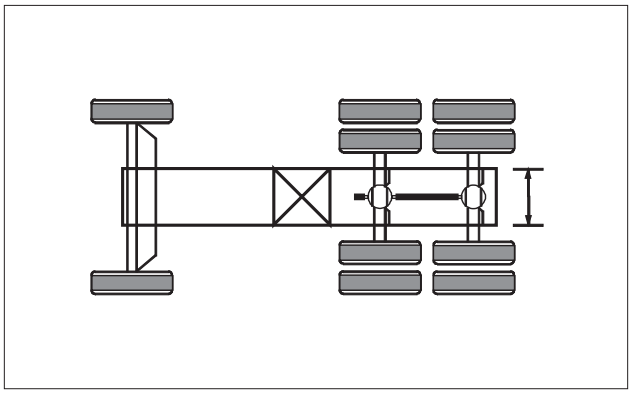
The alignment system will establish the Geometric Centerline.

Frame Centerline Alignment



Frame offset angle is the angle of the frame referenced to the sensor centerline. This angle is calculated by the aligner when frame offset measurements are entered into the aligner.

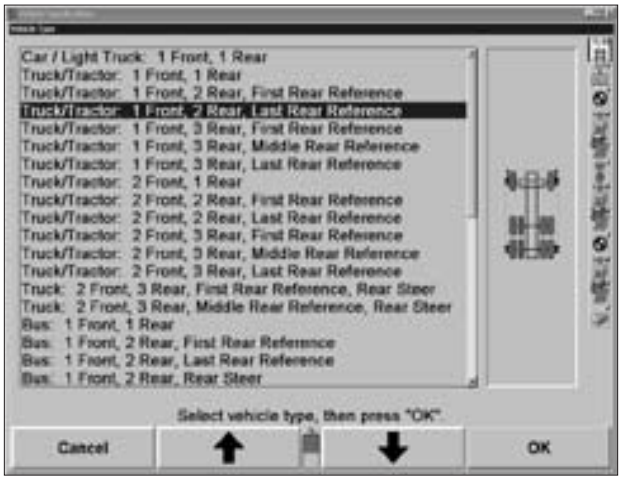
Separation



Separation is the distance between the reference axle adjustment points. This distance may be measured and entered into the aligner before adjusting thrust angle to allow the aligner to calculate how much the axle must be moved at the adjustment point.

Advantages of Computerized Alignment

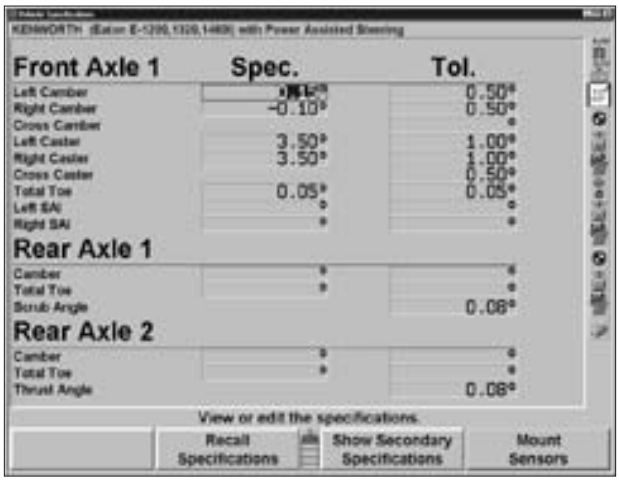
WinAlign® HD Software



WinAlign®HD software supports more than 60 customized truck, trailer and bus alignment procedures as well as passenger car and light truck alignment.

A customized HD specification data base supports most vehicle manufacturers by simply scrolling to the specific model being aligned.

Vehicle Specifications



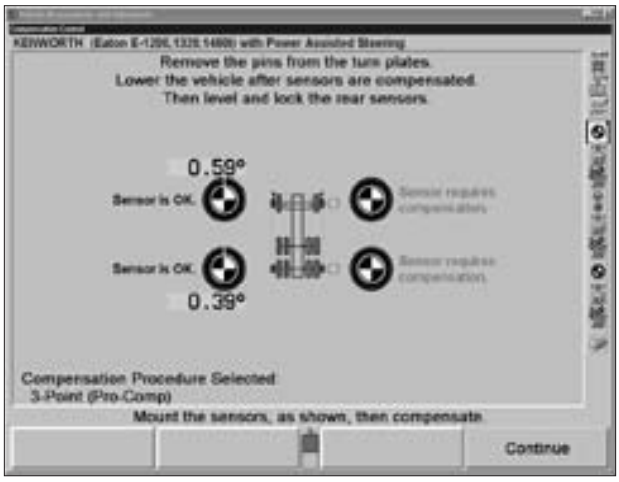
The "Vehicle Specifications" primary screen displays the identification and alignment specifications for the vehicle chosen.

The technician may be asked to enter a reference diameter. He can measure the front tire diameter and enter that value in "Reference Diameter."

When activated, *Express*Align® tool bar (visible in top, right hand corner of aligner screen) automatically shows the customized alignment path for the vehicle selected.

*Express*Align allows movement in procedure by using the mouse and selecting the respective icon relative to sensor location.

Compensation Control Screen



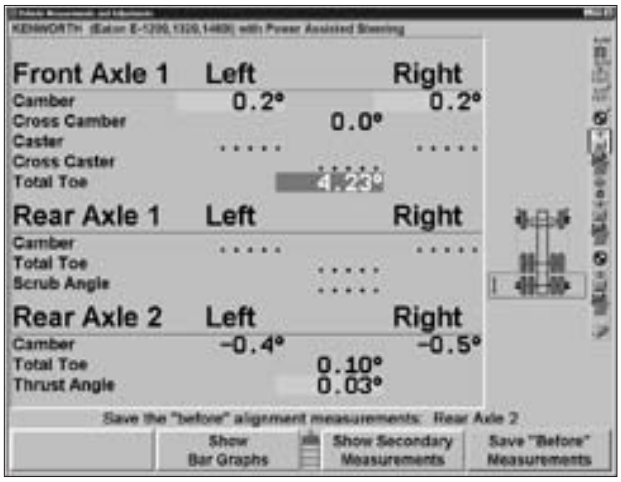
Pro-Comp® allows the technician to mount and compensate one sensor at a time or four technicians to mount and compensate at one time.

Pro-Comp tracks the amount of runout at each wheel position once compensation is complete and flags the technician when excessive runout exists.

Pro-Comp continuously tracks runout at each wheel so the need to keep the wheel adapters straight up and down is no longer necessary.

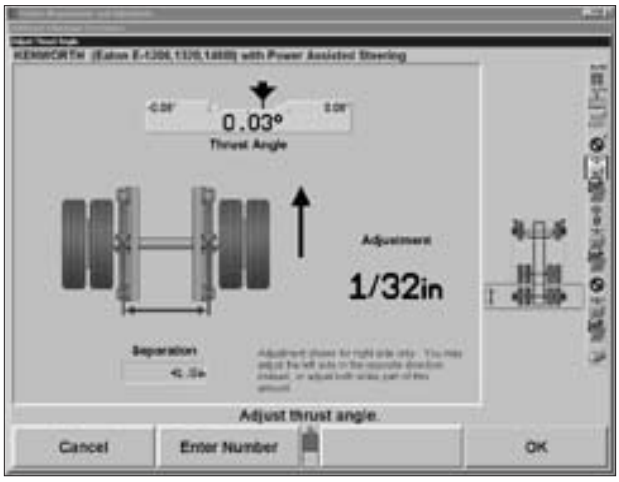
A self centering wheel adaptor centers itself and remains centered as the technician clamps the adapter to the rim (18" - 24" diameter capacity).

Precise Measurement Display



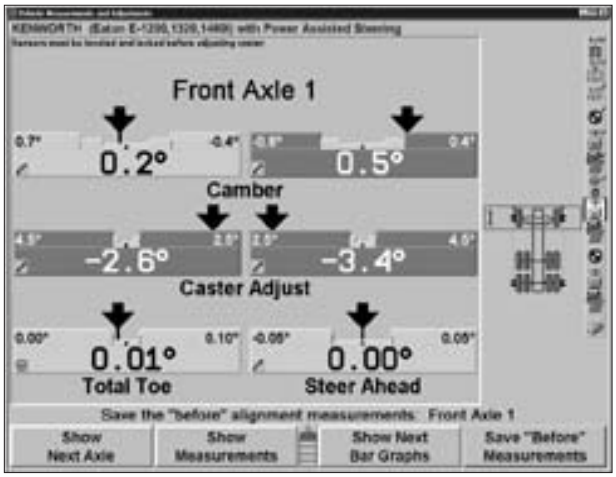
WinAlign®HD provides precise measurements and display. DSP500T Sensors with optional wireless high frequency spread spectrum transmitters allow quick set up. Measurements are compared with the manufacturers specification and results are shown on the vehicle measurement display screen. Easy-to-read color coding identifies in- and out-of-specification measurements.

Automatic Calculation



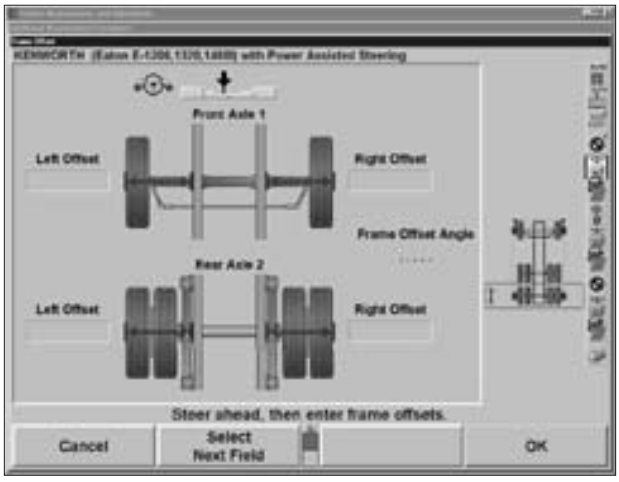
WinAlignHD automatically calculates the correction required. As the adjustment is made, the arrow moves across the bar graph target guiding the technician. When the adjustment comes within specification the bar graph changes from red to green.

Print Any Screen



WinAlignHD allows the user to print any screen for records or to show the vehicle owner the need for service. Before and after alignment measurement screens can be printed to show any out-of-spec. condition. Screens can be printed anytime as a guide for the technician.

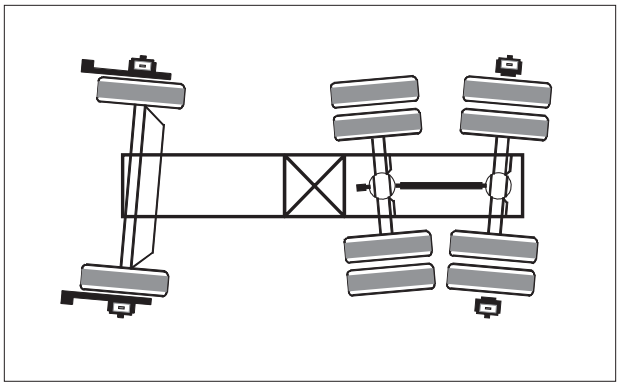
Frame Offset



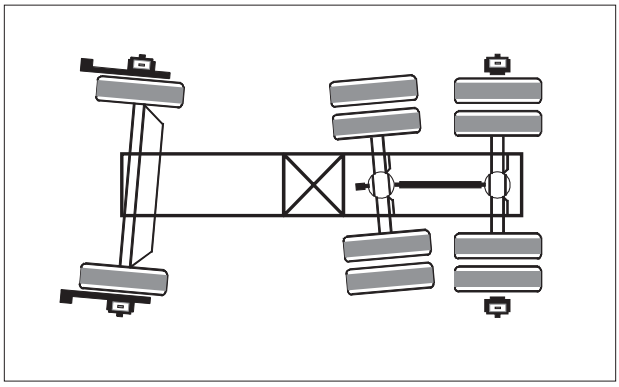
WinAlignHD allows frame offset measurements to be input and displays frame offset angle, recalculating thrust angle from the geometric centerline of the frame.

Total Alignment

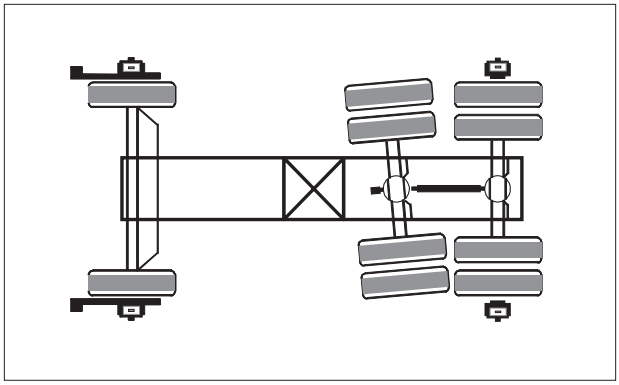
In the total alignment procedure, every axle on the vehicle is measured and the axles are set parallel – so all the wheels roll in the same direction, minimizing rolling resistance.



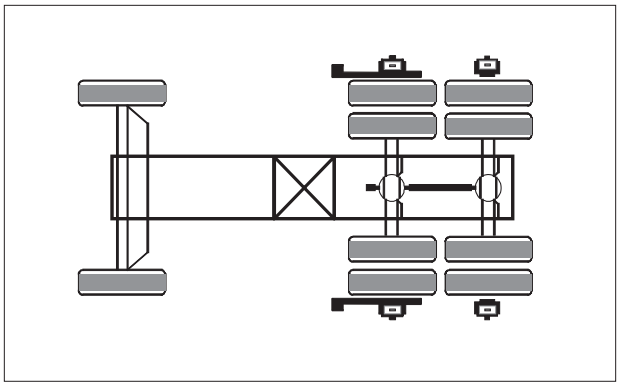
1. Electronic sensors are mounted on the steer axle and on one of the tandem drive axles (the reference axle). The sensors are compensated for runout.



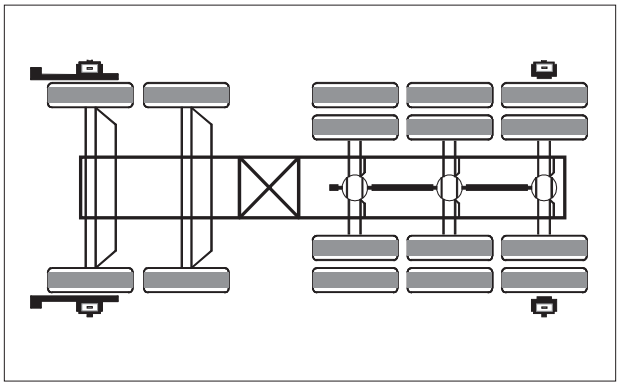
2. The rear reference axle is measured to determine the thrust angle. If adjustable, it is aligned to point down the frame centerline.



3. The steer axle is aligned to the rear reference axle.



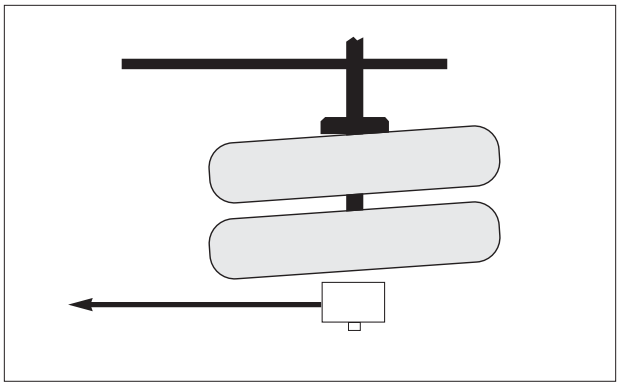
4. Sensors are moved from the front axle to the second rear axle. This axle is aligned to the reference axle.



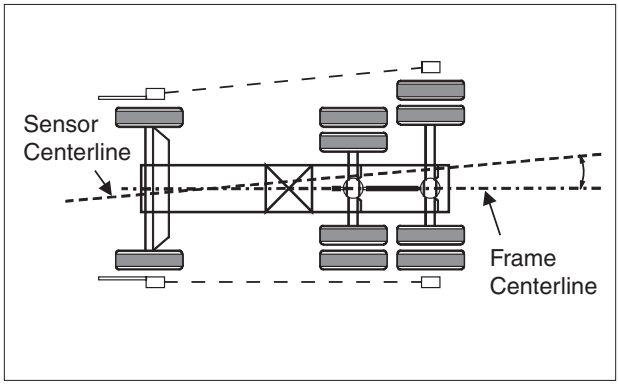
For other vehicle configurations, similar procedures are followed, aligning all axles to a reference axle. 37 pre-programmed procedures are built into this system's software.

Recognizing Factors That Can "Fool" the Alignment Technician

A computerized alignment system should have the capacity to recognize several factors that can affect alignment.



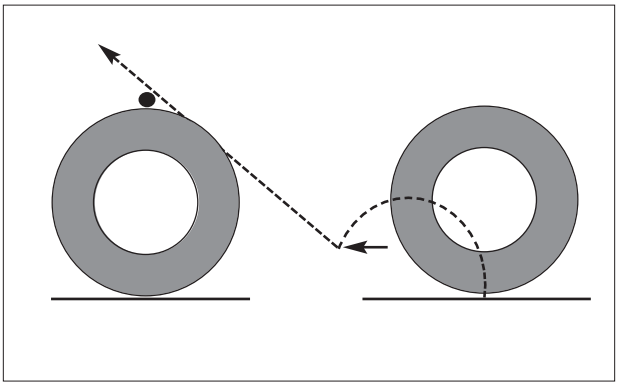
Compensation for Runout
Runout, due to bent or distorted rims, is common on heavy duty trucks and trailers. The aligner electronically compensates each sensor and correctly measures where the axle points.



Identifies and Corrects for Offset
Axle offset on heavy duty trucks and trailers is due, for example, to mismatched rims. The aligner allows the technician to measure the distances and input those measurements, automatically correcting for offset.

Wheel Balance and Its Effect on Tire Wear

When aligning the wheels don't forget about the importance of proper balance. Maximizing tire wear requires proper balance in addition to alignment.



When a wheel and tire assembly is in balance, gravity will not allow it to rotate from a stopped position. If the assembly is out of balance, gravity will force it to rotate when the heavy portion is in any position but straight down.

When the wheel is put in motion, centrifugal force acts on the heavy spot, causing the rotating assembly to pull away from its axis.

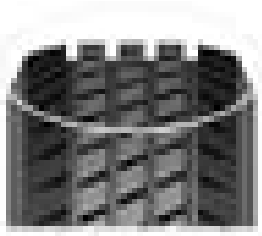
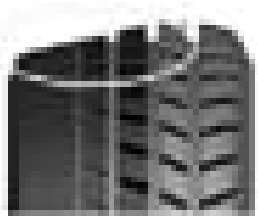
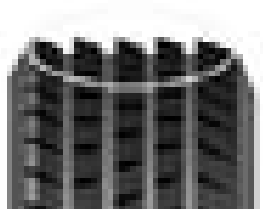
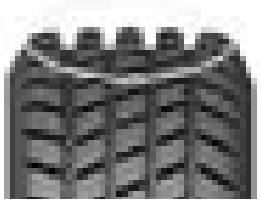
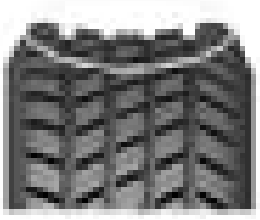
The resulting force causes the wheel to "hop." This causes vibration and increased tread wear in the form of "cupping."

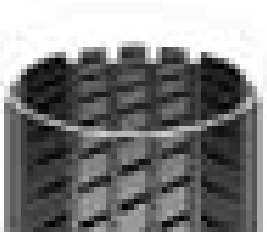
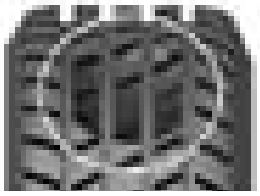
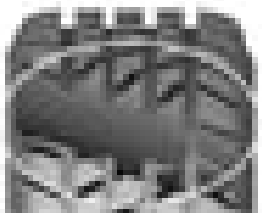
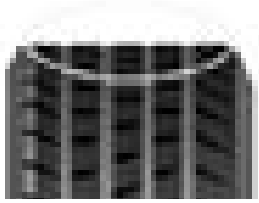
Diagnostic

Road Test Analysis

1. Vehicle manufacturer _____ Model _____ Year _____
2. Suspension (rear) type _____
3. Tire Construction _____
4. Mileage _____
5. Power Steering or Manual Steering _____
6. Front axle manufacturer and I.D. _____
7. Verify ride complaint _____
8. If possible, test the truck in complaint condition _____
9. Verify suspension application _____ Correct _____ Incorrect _____
10. Is the truck driven by more than one driver? Yes ___ No ___
11. If more than one driver, are all experiencing the same problem? Yes ___ No ___
12. At what speed does the problem occur? _____
13. Did the problem come about gradually or all at once? _____
14. Does a change in speed effect the condition; and if so, how? _____
15. Did the problem exist from new? Yes ___ No ___
16. Does it pull left or right? Yes ___ No ___
17. Does it vibrate/shimmy? Yes ___ No ___
18. Any abnormal noise? Yes ___ No ___
19. Any excessive steering effort? Yes ___ No ___
20. Excessively loose steering? Yes ___ No ___
21. Poor returnability? Yes ___ No ___
22. Poor stability/wander? Yes ___ No ___
23. Does braking change the condition; if so, how? _____

Irregular Tire Wear Guide (Steer Tires)

Description	Appearance	Possible Cause	Solution
 ***Shoulder step wear***	Even wear across the center with worn strips around the shoulder.	Typical of a radial ply rib type.	Rotation.
 ***Full shoulder wear***	Excessive wear extended across the entire shoulder rib to a major tread groove.	Scrubbing due to a rear axle misalignment.	Measure and align all wheels. If wear is severe, rotate tires.
 ***Feathered or sawtoothed wear***	Tread ribs worn so that one side is higher, resulting in step-offs across the tread.	Scrubbing due to incorrect alignment, front and/or rear defective suspension or steering components.	Replace worn parts, align vehicle, and if wear patterns are severe, rotate tires.
 ***Erosion/river channel/wear***	Circumferential wear along the rib edges next to major tread grooves.	Characteristic of slow wear rate of radial tires on free rolling axles.	This wear should not be a concern unless the wear becomes too deep. Tires can be rotated to drive axles at this point.
 ***Over-inflation wear***	Excessive wear in the center of the tread – when properly inflated, the tire appears to cup when viewed across the tread face.	Over-inflation expands the tire forcing more wear in the center of the tread.	Keep tires properly inflated.

Description	Appearance	Possible Cause	Solution
 ***Under-inflation wear***	Tread is worn unevenly toward the edges of the tire – when properly inflated the tire appears round when viewed across the tread face.	Under-inflation causes the tire to collapse, forcing more wear on the edges of the tread.	Keep tires properly inflated.
 ***Cupping/scallop wear/ dished out areas***	Localized patches of fast wear creating a scalloped appearance.	A result of moderate to severe assembly out of balance condition.	Diagnose imbalance condition. Tires should be rotated to drive axle.
 ***Diagonal wear - flat spots worn diagonally***	Diagonal wear - flat spots worn diagonally. Localized flat spots across the tread, often repeating around the tread circumference.	Runout and/or out of balance in conjunction with a slow rate of wear. Can also be caused by a loose wheel bearing.	Mount as outside drive dual with change in rotation of tire.
 ***Out of round tire***	Tread depth varies around tire with maximum difference approximately 180 degrees apart.	Usually a result of excessive radial runout or non-uniformity in the rotating assembly.	Replace or correct as necessary. Rotate tire to trailer dual.
 ***Overall fast wear*** - *good wear pattern, but fast rate of wear*	Even wear across tread face and around tire circumference.	Heavy axle loads; such wear often occurs on short wheelbase tractors and on long wheelbase straight trucks.	Carefully match equipment with service requirements. Consult vehicle and tire manufacturers when specifying equipment or replacing tires.

Troubleshooting Guide

Symptom	Possible Cause
Pull Left/Right	Uneven tire pressure
	Uneven tread wear
	Mismatched tires
	Uneven camber
	Uneven caster
	Brake drag
	Suspension/frame sag
	Unbalanced power assist
	Bent spindle
	Worn suspension components (front/rear)
	Excessive tandem scrub
Centerline Steering Error	Incorrect front toe
	Rear wheel misalignment
	Excessive steering and suspension play
	Excessive gearbox play
	Gearbox loose at the frame
Shimmy	Excessive positive caster
	Wheel imbalance
	Defective suspension and steering components
	Excessive wheel and tire runout (lateral)
	Worn tires
	Under inflation
	Steering gear loose
	Excessively loose wheel bearings
	Ply separation or blister
	Improperly torqued lug nuts
Vibration	Wheel imbalance
	Excessive wheel and tire runout (axial)
	Drum imbalance
	Drive shaft imbalance
	Defective u-joints
	Defective wheel bearings
	Improper tire inflation
	Drivetrain misalignment
	Defective shock or shock mounting
	Defective tire

Troubleshooting Guide (cont.)

Symptom	Possible Cause
Noise (abnormal)	Defective wheel bearing
	Overinflation
	Coarse tread pattern
	Incorrect alignment (all wheels)
	Incorrect turning angle
	Loose or rubbing suspension or steering component
	Driveline misalignment
Hard Steering	Low air pressure
	Steering gear binding
	Steering lubricant low
	Excessive positive caster
	Defective power steering belt
	Power steering fluid level low
	Power steering pressure low
	Steering and suspension component dry or binding
Loose Steering	Excessively loose wheel bearings
	Worn steering and suspension components
	Steering gear assembly loose on mounting
	Excessive internal wear in steering gear
	Loose or worn steering shaft coupling
	Steering gear misadjusted
Excessive Road Shock	Excessive positive caster
	Low air pressure
	Worn tires
	Wrong type tire
	Wrong shocks
	Worn shocks
	Springs worn or sagged
Braking Instability	Brakes incorrectly adjusted
	Contaminated brake linings
	Defective suspension components
	Incorrect alignment
	Excessive negative caster
	Uneven or low tire pressure

Troubleshooting Guide (cont.)

Symptom	Possible Cause
Poor Returnability	Incorrect caster
	Low air pressure
	Binding suspension and steering components
	Binding steering gear
Wander/Instability	Incorrect alignment
	Worn tires
	Low air pressure
	Mismatched tires
	Worn suspension and steering components
	Worn or loose steering gear
	Misadjusted steering gear
	Excessively loose wheel bearings
Squeal/Scuff on Turns	Worn tires
	Low tire pressure
	Incorrect turning angle
	Poor driving habits
	Worn suspension or steering components
Excessive Body Sway	Worn shocks or mountings
	Broken or sagging springs
	Uneven vehicle load
	Uneven tire pressure

Power Steering Troubleshooting Guide

Symptom	Possible Cause
Insufficient Assist	Low fluid
	Incorrect fluid
	Loose/worn belt
	Defective pump
	Restricted fluid passages
	Mechanical bind
Vehicle Pulls	Inoperative control valve
	Misadjusted control valve
Fluid Leaks	Loose hose connection
	Defective hose
	Damaged seals
	Fluid level too high
Excessive Noise	Low fluid level
	Loose/worn belt
	Defective pump
	Restricted fluid passages
	Defective relief valve
Poor Returnability	Steering column misalignment
	Yoke plug too tight
	Valve assembly binding
	Contaminated fluid
	Defective u-joints

Facility Factors

How Much Space is Required?

Wheel alignment for heavy duty vehicles is not space intensive.

The alignment console is usually mounted on a mobile cabinet that can be rolled to the vehicle. Overall dimensions of a console with a 19" monitor and truck & bus sensors mounted are 65" high by 33" deep by 72" wide.

Space for the console and the vehicle, and working room for the technician is all that is required.

Is a Pit Rack Needed?

A pit rack has definite advantages in providing room underneath a vehicle for inspection, alignment and suspension repairs.

However the only equipment needed for toe, scrub and thrust angle (the most important adjustments to be made) are the alignment system, turning angle gauges (standard equipment with the Hunter system) and a jack for lifting the vehicle during the procedure.

Technicians and Training

Finding an Alignment Technician

Most experienced heavy duty technicians can learn alignment quickly, especially with the help of a computerized system and on-site training.

Alignment Training

Hunter Engineering Company routinely offers heavy-duty truck alignment courses. These courses provide extensive hands-on experience with equipment and vehicles.

On-site training is offered at the time of equipment installation, with retraining available when new technicians are hired.

Training in Merchandising of Alignment

Surprisingly, many experienced people in the trucking industry have only a minimal understanding of wheel alignment and its effects on tire wear, fuel consumption and vehicle handling. Because of this, the technician or service manager may need help in merchandising alignment service.

Hands-on training in alignment merchandising should be as much a part of the equipment ”package” as operations training. See your local Hunter representative for details.

Pamphlets and brochures can be used at the shop location and in working with fleet management.

Truck/Bus/Trailer Alignment Procedures

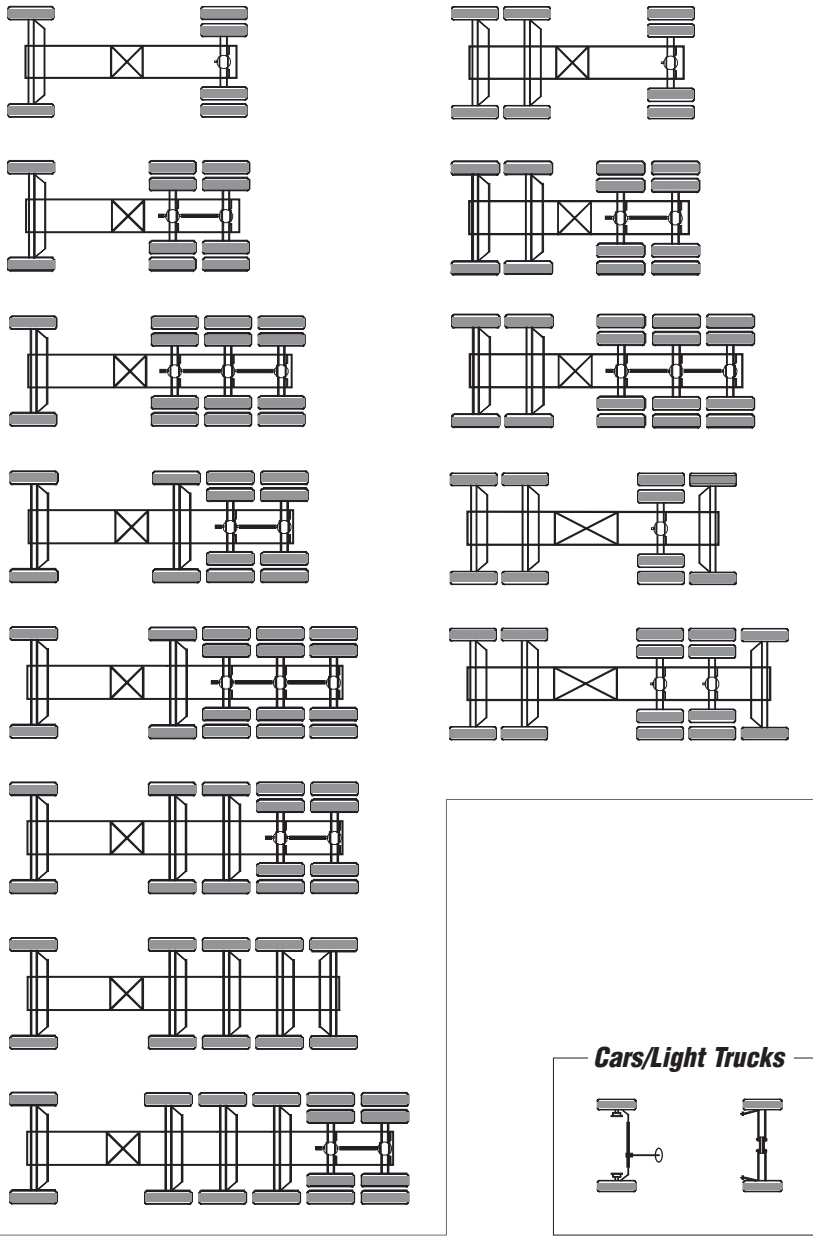
To properly align heavy-duty trucks, buses and trailers, it is necessary to first determine the axle configuration. On vehicles with more than two axles it is also necessary to determine which axle should be used as a reference axle. Some axles are not adjustable, therefore that axle must be used as the reference axle.

The other axles are then aligned to the non-adjustable reference axle of an all wheel alignment. If all axles are adjustable, the rearmost drive axle is generally used as the reference axle.

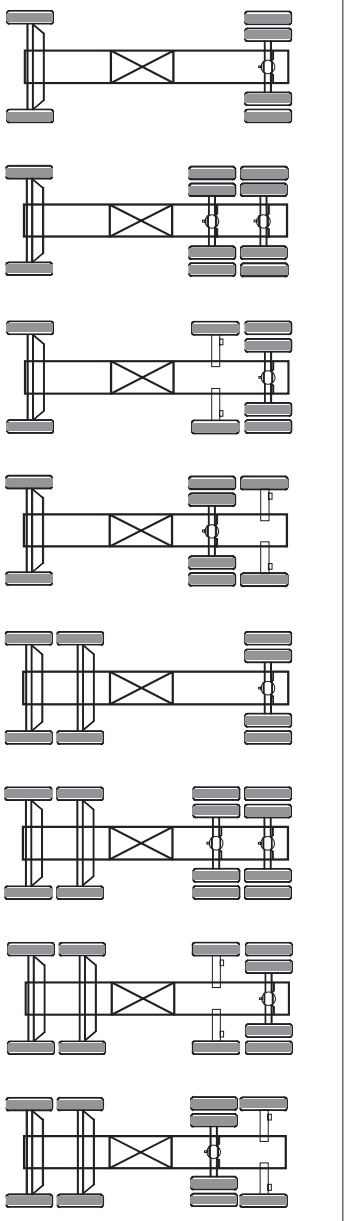
Use the following diagrams to determine which alignment procedure should be used for the vehicle being aligned.

Truck/Bus/Trailer Axle Configurations

Trucks



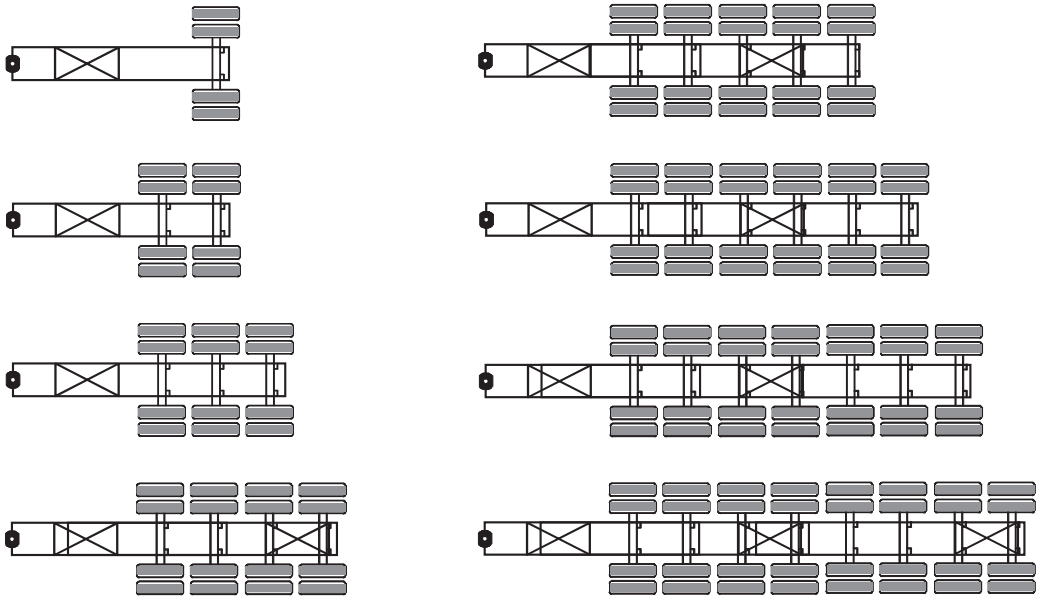
Busses



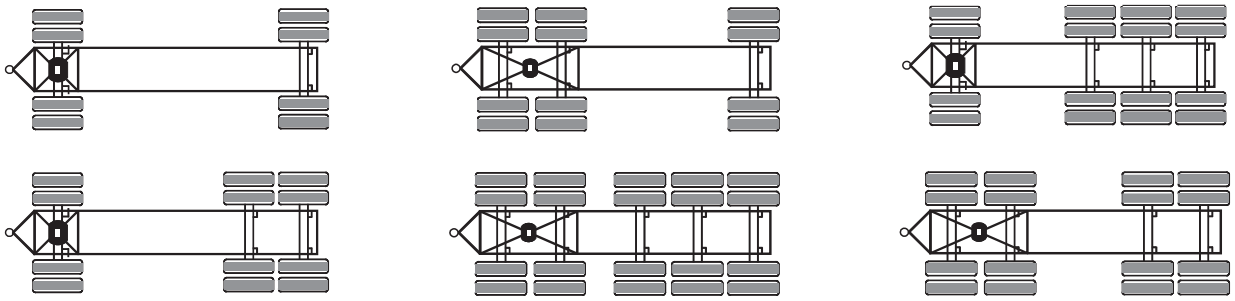
Cars/Light Trucks

Truck/Bus/Trailer Axle Configurations (cont.)

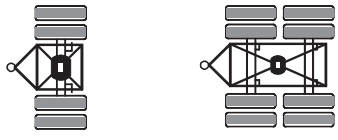
Semi-Trailers



Full Trailers



Dollies



Glossary

Ackerman Principle: An alignment principle based on vehicle tread width and wheelbase upon which turning angle is computed.

Ackerman Arm: A steering component, which provides interconnection between the outer tie rod and spindle.

Alignment: The process of measuring and adjusting the position of all wheels attached to a common chassis.

Angle: Two intersecting lines that are not parallel.

Arc: Any part of a circle or a curved line.

Axial Play: Vertical movement of the wheel and tire assembly when inspecting a kingpin.

Balance: This term is used to describe having equal weight distribution about the circumference of a wheel and tire assembly.

Bead: A wire steel coil forming an anchor for individual plies and rim attachment of a tire.

Bellows: A rubber type seal, which is folded to allow for a telescopic action. Normally referred to as a bellows boot.

Bias Belted: A bias ply tire that has reinforcing strips or belts under the tread section.

Bias Ply: A tire constructed of alternate plies, which intersect the tire centerline at approximately 35 degrees.

Body Roll: The leaning of the vehicle body while cornering.

Braking Control: Vehicle stability related to the reaction under all stopping conditions.

Bushing: A component made of metal or rubber-type material, used to isolate interconnected moving parts.

Cam Bolt: A bolt and eccentric assembly which, when rotated, will force components to change position.

Camber: The inward or outward tilt of the wheel.

Camber Roll: A change in camber brought about by suspension changes while cornering.

Caster: The forward or rearward tilt of the steering axis.

Center Bolt: A bolt that provides centering and attachment of an axle and spring assembly.

Centerline Steering: A centered steering wheel while the vehicle is traveling a straight ahead course.

Chassis: All major assemblies on a vehicle including suspension, steering, drivetrain, and frame. Everything, except the body.

Circumference: The total distance around a circle.

Concentric: Two or more components sharing a common center.

Conicity: A tire irregularity, which causes the tire to take the shape of a cone when inflated and loaded. This may generate a lateral force.

Contact Area: The total amount of tread surface that contacts the road.

Cornering: The ease at which a vehicle travels a curved path.

Cross Tube Assembly: Two tie rods and a tube, which transfers the turning effort to the opposite side of the vehicle.

Curb Weight: The overall weight of a vehicle, less passengers, luggage, or load.

Degree: A unit of measurement to describe an angle.

Dial Indicator: An instrument used to measure and display linear displacement. Measurement is displayed on a dial face and the scale is commonly graduated in thousandths.

Directional Stability: The tendency for a vehicle to maintain a directed path.

Drag Link: A tube or rod used for interconnection between Pitman Arm and tie-rod assemblies.

Dynamic Balance: This normally refers to the balance condition of a wheel and tire assembly in motion.

Foot Pound: A unit of measurement used to describe torque force.

Frame Angle: The angle formed by a horizontal line and a line drawn parallel to the frame.

Geometric Centerline: A line drawn between the midpoint of the front axle and the midpoint of the rear axle.

Horizontal: Parallel or level with the plane of the horizon.

Hub: The assembly that houses the bearings about which the wheel and tire assembly rotates.

Hydraulic Pump: A power driven device generating constant volume and pressure.

Included Angle: The sum of the angles, camber and SAI.

Independent Suspension: A suspension system that provides an isolated mounting for each wheel to the chassis.

Individual Toe: The angle formed by a horizontal line drawn through the plane of one wheel versus a centerline.

Intersect: The crossing point of two lines.

Jounce Travel: A suspension moving up through its travel.

Kinetic Balance: The balance condition of a rotating wheel related to force generated in a vertical plane.

King Pin: A pin used to attach a spindle to an axle.

Lateral Run-out: Side-to-side movement with a rotating wheel or tire.

Lead: A slight tendency for a vehicle to move away from its directed course.

Linkage: A series of rods or levers used to transmit motion or force.

Load Range: A system used to describe the service or weight limitations of a tire.

Memory Steer: A condition where the wheels, rather than returning to straight ahead, tend to remember and seek a previous position.

Millimeter: A unit of linear measurement. One millimeter is equivalent to 0.039 inches.

Minute: A unit of measurement used to describe an angle. One minute is equivalent to 1/60 of one degree.

Offset: The lateral displacement of a wheel or axle in respect to a centerline.

Oscillate: A back and forth motion at a specific frequency.

Out-of-Round: A wheel and tire irregularity in which one or both are not concentric with its axis of rotation.

Overinflation: Inflation pressure beyond that which is recommended.

Oversteer: A characteristic in which a vehicle has a tendency to turn sharper than the driver intends.

Parallelogram Steering Linkage: A steering linkage design where if all pivot points were connected by lines, these lines would be parallel.

Perpendicular: Being at right angles.

Pitman Arm: A steering component that provides interconnection between the steering gear sector shaft and the steering linkage.

Ply Rating: A method of rating tire strength. Not necessarily indicative of the actual number of plies used.

Power Steering: A steering system that incorporates hydraulics to assist in the steering of the wheels.

Pre-load: A predetermined amount of load or force applied during assembly to prevent unwanted play during actual operation.

Pull: The tendency for a vehicle to steer away from its directed course.

Radial Play: Any lateral movement of the wheel and tire assembly when inspecting a ball-joint or kingpin.

Radial Ply Tire: A tire construction type with alternating plies 90 degrees to the tire bead.

Radius: The distance from the center to the outer edge of a circle.

Rear Axle Departure Offset: The amount in inches from the midpoint of the steer axle (or kingpin on a trailer), where the projected thrustline intersects.

Rebound: A suspension moving down through its travel.

Recirculating Ball Steering Gear: A steering gear design that is made up of a worm shaft, ball nut, and two recirculating ball circuits.

Returnability: The tendency of the front wheels to return to a straight ahead position.

Road Crown: The slope of a road from its center.

Road Feel: Necessary feedback transmitted from the road surface up to the steering wheel.

Road Isolation: The ability of a vehicle to better separate road irregularities from the driver and passengers.

Road Shock: An excessive amount of force transmitted from the road surface up to the steering wheel.

Scrub Radius: The radius formed at the road surface between the wheel centerline and steering axis.

Semi-Integral Power Assist: A power assist system using a hydraulic pump and a power cylinder in conjunction with the steering gear.

Setback: The angle formed between a centerline and a line perpendicular to the front axle.

Shim: Thin material of fiber or metallic makeup used to take up clearance between two parts.

Shimmy: A violent shake or oscillation of the front wheels transmitted up to the steering wheel.

Shock Absorber: A suspension component used to dampen spring oscillation.

Solid Axle Suspension: A suspension system consisting of one steel or aluminum I-beam extended the width of the vehicle.

Short Long Arm (SLA): An independent suspension design incorporating unequal length control arms.

Spindle: A component on which a wheel and tire assembly rotates.

Stability: The tendency of a vehicle to maintain a directed course.

Stabilizer: A steel bar used to minimize body roll.

Steering Axis Inclination: The angle formed by an imaginary line drawn through the steering axis versus vertical.

Steering Gear: A mechanical device used to convert the rotary motion at the steering wheel to a lateral motion.

Steering Shaft: A tube or rod, which interconnects the steering wheel to a lateral motion.

Strut: Any support used between two parts.

Suspension: An assembly used to support weight, absorb and dampen shock, help maintain tire contact and proper wheel to chassis relationship.

Suspension Height: The specified distance between one or more points on a vehicle to the road surface.

Tandem Lateral Offset: When the geometric centerline does not cross the midpoint of all axles.

Tandem Scrub Angle: The angle formed by the intersection of horizontal lines drawn through each rear axle when total toe and the offset is zero.

Thrust Angle: The angle formed by thrustline and geometric centerline.

Thrustline: A bisector of rear total toe.

Tie Rod Assembly: The outer most assemblies on a parallelogram steering linkage. These assemblies are attached to the drag link and Ackerman Arms.

Tie Rod End: The ball and socket assembly of a tie rod.

Tie Rod Sleeve: A threaded tube that provides connection and adjustment of a tie rod assembly.

Tire Force Variation: A tire irregularity, in which there is a difference in radial stiffness about the circumference of the tire.

Toe: The comparison of a horizontal line drawn through both wheels of the same axle.

Turning Angle: The difference in the turning angle of the front wheels in a turn.

Torsion Bar: A spring steel bar used in place of a coil spring.

Tracking: The interrelated paths taken by the front and rear wheels.

Treadwidth: The dimension as measured between the centerlines of the wheels on the same axle.

Treadwear Indicators: Ridges molded between the ribs of the tread that visibly indicate a worn tire.

Under Inflation: Air pressure below that which is specified.

Understeer: A characteristic in which a vehicle has a tendency to turn less than the driver intends.

Vertical: Being exactly upright or plumb.

Vibration: To constantly oscillate at a specific frequency.

Waddle: The lateral movement of a vehicle, usually caused by some type of tire or wheel imperfection.

Wander: The tendency of a vehicle to drift to either side of its directed course.

Wheelbase: The dimension as measured between the center of the front and rear axles.

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