OPTIMAAX® Liftable Forward 6×2 Axle and Suspension

The needs of the Commercial Vehicle Market can vary depending on the market segment.

The on-highway segment values weight, ride and handling performance, durability, reliability, and cost. Traditionally, the on-highway segment has been dominated by 6x4 configured vehicles. However, as fleets continue to target improved fuel economy and government regulation mandates a substantial reduction in exhaust emissions, 6x2 configurations have risen in popularity. This movement for greater efficiency has driven the market to look toward the next generation of 6x2s.

6×2 - Background

Simply stated, a 6x2 vehicle configuration consists of three axles: one front steer non-driven axle, one rear axle that is driven and another rear axle that is non-driven or "dead." Since non-driven axles contain no internal gearing to provide power to the wheels of the axle, internal friction or losses due to lubricant churning is eliminated, which in turn reduces parasitic losses in the drivetrain. The non-driven axle still carries the same load weight rating as a second driven axle. Thus, the load weight rating of the tandem (gross axle weight rating or GAWR) does not change for a 6x2 vs. a 6x4 configured vehicle.

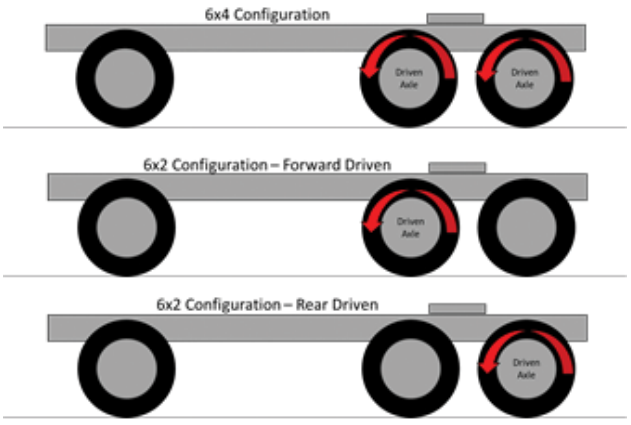
The 6x2 axle configuration has long been in existence in the Class 8 truck industry; going through phases of popularity starting in the 1980's. The 6x2 has been most prevalent in Europe where the vehicle consists of a tandem axle configuration with a liftable dead axle in either the forward or the rear position with the rear "tag" position being the more common. The 6x2 adoption rate has not increased dramatically in North America due to a combination of factors, most notably traction performance and resale value. This trend is expected to change and the popularity of 6x2s is expected to increase given upcoming greenhouse gas (GHG) rules in the U.S. regarding fuel economy. The U.S. Environmental Protection Agency suggests in its published GHG regulations that the 6x2 adoption rate could increase to 30% by the year 2027.

Most fleets in North America that are using 6x2s in their operation employ the use of a non-liftable dead tag axle, which is placed behind the drive axle. The tag axle always maintains contact with the road surface, which can lead to the spinning of the drive wheels in certain conditions such as snow and ice, thus causing insufficient traction.

As for resale, 6x4s compose the majority of the tractor population in the U.S., so their popularity alone has given them higher residual values. One concern that has surfaced is the resale value of 6x2s may be lower than that of 6x4s. However, certain fleets report that resale value has not been a concern, especially when fuel economy benefit can be demonstrated.

Powered Axles

In a 6x4 configuration, power is distributed evenly between both of the rear tandem axles, whereas in a 6x2 configuration only one axle is powered with the other axle being non-powered or "dead." The powered axle in a 6x2 configuration can be either the forward tandem or the rear tandem, but the more common arrangement in the field today features the forward tandem axle as the driven axle.



Liftable Axles

Today's typical 6x2 non-liftable dead tag axle configurations are designed to add or remove suspension air pressure to the non-powered axle while maintaining or maximizing suspension air pressure on the drive axle. This additional suspension air pressure helps to provide traction to the driven axle. However, with the non-driven axle still in contact with the road surface, the traction provided to the driven axle is still not optimal. Further, the load on the non-driven axle can adversely affect the tire wear on the drive axle as well as contribute to wear on wheel ends simply due to the additional duty cycle of the equipment being in use. The additional rolling resistance caused by this non-driven axle can also limit the fuel economy benefits of the 6x2 configuration.

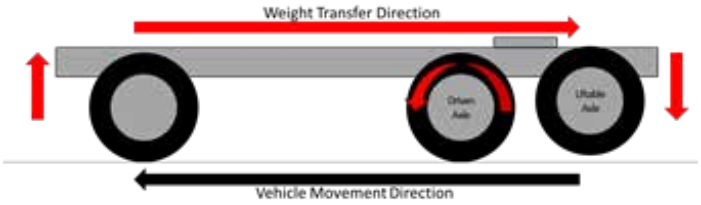
Lifting the non-driven axle when the tractor is in a Bobtail configuration, or connected to an empty or lightly loaded trailer, can provide multiple benefits.

1. **It can increase the traction of the driven axle. This applies not only when on the road but also when backing under a trailer on loose gravel or in slick conditions.**
2. **It can help reduce tire wear by not having the tires in contact with the ground when not necessary. In addition, this can help reduce wear on tires due to lower tire scrub, which also improves maneuverability and handling.**
3. **It can reduce wear and tear on wheel ends and brakes due to the reduction of time in operation.**
4. **Finally, it can reduce the additional drag of the non-driven axle being on the ground, which helps lead to improved fuel economy of up to 2%.**

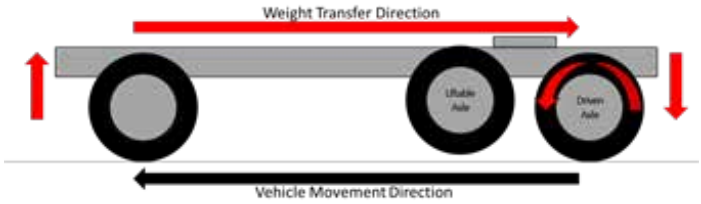
Which Axle to Lift?

While lifting either the forward or the rear tandem can provide greater traction in a 6x2 than having both axles in constant contact with the ground, in most cases the ability to lift the forward tandem axle is favorable versus lifting the rear. Weight load distribution plays a key factor in this.

The 5th Wheel / King Pin position on a typical tractor is usually placed between the forward and rear tandem axles. If the rear tandem axle were lifted, the load from the 5th Wheel would apply a cantilever behind the forward tandem axle, which in turn would remove load from the front steer axle and negatively impact steering control. Conversely, setting the 5th Wheel too far forward to offset this could result in overloading the front steer axle.



Alternately, if the forward rear axle is lifted, there is no cantilever effect and the 5th Wheel weight is shared between the rear axle and the front steer axle. This configuration transfers a minimal portion of the load to the steer axle and limits the potential for overloading the axles if the rest of the chassis components are specified appropriately.



This allows for optimal weight distribution between the rear most axle and the steer axle.

Lastly, moving the 5th Wheel position for a certain configuration's optimal weight distribution may not be allowable in specific states or municipalities so this must be taken into consideration.

OPTIMAAX®

Hendrickson's OPTIMAAX® system is an innovative 6x2 solution designed to help fleets save fuel cost, tire wear and weight with comparable handling to 6x4 tandem axle configurations. Operating as a liftable axle in the forward tandem position, this system provides versatility for fleets with variable loads. The fully automated control module eliminates driver intervention and allows the tractor to adapt to the requirements of the load; raising the axle when the additional capacity is not needed and lowering the axle to distribute the load evenly when required. OPTIMAAX also provides load equalization between the tandem axles which, when in the lowered position, optimizes braking performance and helps fleets comply with applicable state bridge law regulations.

OPTIMAAX® Features and Benefits

- **Savings**
  - Saves up to 400 lbs. versus a traditional 6x4
  - Promotes up to 5% improved fuel economy*
    - In general, 6×2 suspension systems can provide up to 3.5% reduction in fuel consumption compared to similar 6×4 tractors**
    - OPTIMAAX can provide up to 2.3% additional fuel economy improvement through lifting the non-drive axle (4×2 configuration)***
  - Lifted axle saves on tire wear to help reduce tire as well as brake and wheel end maintenance costs
  - Savings on toll charges through fewer axles on the ground
- **Traction and Handling**
  - Provides increased traction by lifting the forward tandem, thereby increasing drive axle load
  - Helps improve traction when backing under trailers in soft soil or wet conditions versus traditional 6×2
  - Maintains vehicle handling and maneuverability characteristics by keeping the drive axle behind the 5th Wheel
- **Automated Controls**
  - Proprietary program logic controls lift axle movement and load transfer
  - Fully automated controls eliminate need for driver intervention
  - Automates axle lowering and lifting by sensing load

* Compared to 6x4 tandem axle configurations
** Based upon testing conducted by Performance Innovation Transport (PIT) Group of FPInnovations (2013)
*** Based upon independent proving grounds testing commissioned by Hendrickson

Applications

The goal of all trucking fleets is to earn as much profit as possible. To do so, they need to move cargo as much as possible. However, in certain applications, it is not feasible to always run with a fully loaded trailer. For those applications, consider specifying OPTIMAAX®. Varying load applications are ideal for OPTIMAAX because it offers the flexibility and carrying capacity of either a 6×4 or 4×2 depending upon the needs of the fleet with each load.

- **Ideal for diminishing load carriers or applications experiencing empty back hauls**
  - Bulk / Tank Haulers
  - Grocery
  - Livestock
  - Beverage
  - Factory Auto Parts Haulers

How Does It Work?

OPTIMAAX considers the weight of the tractor as well as the weight of the trailer to determine when the axle should be lifted or deployed. To accomplish this, the system is programmed, based on the vehicle's specific configuration, to determine the load on the drive axle by measuring the air spring pressure on the drive axle air suspension. The system then converts that pressure to weight. Applying that drive axle weight and using vehicle configuration information, OPTIMAAX then determines the weight on the steer axle. Considering all of these calculations, the system then determines when the non-driven axle should be lifted or deployed based on the load.

Axle lowered for 6×2 configuration — The OPTIMAAX system senses higher load conditions and lowers the non-drive axle

Axle lifted for 4×2 configuration — The OPTIMAAX system senses lighter load conditions and lifts the non-drive axle

System Operation

The OPTIMAAX® system is fully automated so there is no action the driver needs to take when operating the vehicle. The driver only needs to be familiar with how OPTIMAAX functions. There are specific criteria that trigger each of the specific operating modes of the OPTIMAAX system.

- **Park (Axle Lowered)** – OPTIMAAX is designed to deploy (lower) its lift axle when the ignition is off and / or when the parking brake is set. In these conditions, regardless of the load on the axles, the OPTIMAAX would be down and the load would be split 50/50 between the two tandem axles.

- **Empty or Lightly loaded (Axle Lifted)** – When the ignition is on with the parking brake released and the tractor is in either a Bobtail configuration or attached to a trailer that is empty or lightly loaded, OPTIMAAX senses the lightly loaded drive axle and lifts the forward tandem axle based on the programmed controller settings. If the driver stops along the route while the forward tandem axle is in the raised position, the axle will lower when the parking brake is set or when the ignition is turned off. Once the truck resumes, the controller will determine if the axle should be in the raised or lowered position. The axle load threshold which triggers OPTIMAAX to lift is dependent upon the applicable controller settings for the respective tractor specifications.

- **Loaded (Axle Lowered)** – OPTIMAAX is deployed (lowered) when the system senses the load on the drive axle is enough to potentially overload the steer axle or drive axle. For example, when the driver stops to make a delivery with a fully loaded trailer, the OPTIMAAX axle will remain lowered once the parking brake is set. After the trailer is unloaded and if the weight is light enough, the axle will raise once the truck ignition is turned on and the parking brake is released. The typical loading on this particular configuration would be 17,000 lbs. per axle in the tandem on a standard on-highway tractor configured 20,000 lb. per axle GAWR.

Operating Mode		Criteria	Axle Loads (Liftable/Drive)
Empty **Axle Lifted**		**Senses lighter axle load capacity**	**0/12k lbs.**
Park **Axle Lowered**		**Lowers axle with parking brake set**	**6k/6k lbs.**
Loaded **Axle Lowered**		**Senses heavier axle load capacity**	**17k/17k lbs.**

6x2 configurations are supported by leveraging the Automatic Traction Control (ATC) feature within the Anti-Lock Braking System (ABS). These technologies help to enhance vehicle traction and stability.

ABS monitors the individual wheel end speed under driving conditions, and should excessive slip be detected at the drive axle, the ATC limits the wheel spin by either reduction of engine torque or selective brake application.

System Operation *(Cont'd.)*

When used in conjunction with the OPTIMAAX® system, these features go one step further by using the load bias feature of the OPTIMAAX system in conditions when a loss of traction is detected. Load bias is enabled when ATC senses a wheel slip condition, and the ABS / ATC controller sends a Controller Area Network (CAN) signal to the OPTIMAAX controller indicating that ATC is active. The OPTIMAAX system initiates load-bias by dumping (exhausting) the air out of the ride springs on the OPTIMAAX axle. This results in increased load on the drive axle to provide additional traction when the driver needs it.

Once excessive wheel slip ceases or the traction event ends, the OPTIMAAX system reverts to its normal operating condition.

As a driver is operating a tractor equipped with OPTIMAAX, they may encounter various situations that would trigger different reactions from the OPTIMAAX system.

- **Traction Event** – OPTIMAAX uses load biasing to put more load on the driven axle when the traction control senses wheel slip. This will provide additional traction when it is needed.
- **Controller Error (Warning)** – If there is a system fault, the operator would see a "Lift Axle Not Working" warning appear in the Driver Information Display. In this condition, OPTIMAAX would deploy (lower) and equalize the load between the tandem axles.

Operating Mode		Criteria	Axle Loads	Indicator Lamp
Traction Event Axle Dump		ATC senses wheel slip condition	14k/20k lbs.	ATC light
Controller Error Warning		System fault	Loads equalize	Light flashing

Return on Investment

As with any equipment decision, it is important to consider the potential return on investment (ROI) a fleet can expect from their purchase. Hendrickson has developed an ROI calculator to help fleets determine if OPTIMAAX® is the right investment for their business based on the estimated savings over a period of time by entering some basic information. Below is an example.

COST	**Upfront Cost**	
	Real Money Upcharge for OPTIMAAX®	**$3,500.00**

FUEL ECONOMY	**Fuel Savings**	
	6×4 specification current mpg	**7.00**
	6×2 tag mpg = 3.5% increase over 6×4	**7.25**
	Additional 6×2 OPTIMAAX mpg = 2.3% over 6×2 when lifted	**7.41**
	fuel cost per gallon	**$2.43**
	miles per year	**125,000**
	% mileage with lifted axle	**50%**
	Annual Fuel Cost Savings with 6×2 OPTIMAAX	**$1,937.90**

WEIGHT SENSITIVITY	**Weight Savings**	
	Dollars per pound of payload	**$0.0025**
	Estimated weight savings	**400**
	Trips per year	**250**
	Additional OPTIMAAX $ per year over 6×4's	**$250.00**

MAINTENANCE	**Annual Maintenance Savings**	
	Estimated Annual Maintenance Savings	**$100.00**

FINANCIALS	**Total Costs / Return on Investment**	
	Total annual savings over 6×4	**$2,287.90**
	Payback over 6×4 (Months)	**18.4**

The calculator considers some basic entries (highlighted above in blue), including estimated upcharge price for the system, current miles per gallon, cost of fuel, miles per year traveled, estimated percentage of time that the axle would be lifted (based on Bobtail, empty or lightly loaded conditions), number of vehicles in the fleet and number of trips per year to generate estimates for potential annual savings and the time frame it may take to pay back the investment versus a typical 6×4 or 6×2 configuration. In the example shown compared to a 6×4, the OPTIMAAX system may pay for itself in approximately a year and a half, suggesting that the fleet could then add the annual savings of roughly $2,300 per year to their bottom line for the remaining years they operate the vehicle. This calculator is available for use on Hendrickson's website at www.hendrickson-intl.com/OPTMX/index.html.

How to Specify?

Fleets looking to invest in equipment such as OPTIMAAX® are typically very weight sensitive and have usually considered many available options to optimize weight with their vehicle specifications. However, to get the most out of OPTIMAAX, fleets should consider reviewing a few specific items including but not limited to the following:

- Steer axle capacity
- Fuel tanks (capacity & position)
- 5th Wheel slider length
- 5th Wheel position
- Equipment (Moose Bumpers, APU, Racks)
- Frame rail package

There is some important information to gather to help ensure that OPTIMAAX is not only the right suspension but also that it operates to meet / exceed the fleet's expectations of the suspension.

- Type of trailer or application
- Weight Distribution of the tractor and trailer combination from weight scale tickets
  - Loaded
  - Unloaded
  - Partially loaded back haul
  - Bobtail
- Front axle weight (unloaded & loaded)
- Rear tandem weight (unloaded & loaded)
- Empty trailer weight & kingpin load
- Percentage of empty hauls

The master feature code for OPTIMAAX for the Freightliner® Cascadia® is 622-293, Airliner with OPTIMAAX 40,000# Rear Suspension for Liftable Pusher 6×2. This code selects the OPTIMAAX Axle and Suspension for the liftable forward tandem axle along with the OPTIMAAX electronic control unit.

The Hendrickson OPTIMAAX Electronic Control Unit (ECU) is programmed to deploy / lower the liftable forward tandem axle when a fixed, pre-set drive axle load threshold is reached. The controller is pre-set at the vehicle OEM's factory for a truck's specific configuration. The deployment is designed to provide optimum traction and help prevent the steer axle from becoming overloaded. OPTIMAAX ECUs are available with deployment thresholds ranging from 13,000 to 20,000 pounds. The deployment threshold is dependent on the truck's specific configuration. To maximize the benefits of the OPTIMAAX system, the truck should be configured to allow for the highest deployment threshold of the OPTIMAAX axle. Based on the specific vehicle configuration, the ECU selection is determined by the OEM to provide optimum system performance.

Specification Calculator

Hendrickson has created a helpful calculation tool to assist with understanding some of the considerations when specifying OPTIMAAX®. This calculator will help to guide the total vehicle specification to optimize the benefits of the system. Using the Freightliner Cascadia Databook for the weights of each option, this will assist in guiding the selection of OPTIMAAX for a given specification. A few of these major items to consider are discussed in further detail below.

- **Steer Axle** – Increasing the capacity of the steer axle from 12,500 to 13,300 lbs. increases the load that can be carried on the rear tandem axle by 4,500 lbs. as illustrated in the figures below. This allows more opportunity for the lift axle to be raised and helps promote enhanced fuel economy.

- **Fuel Tanks** – 80-gallon left hand and right-hand fuel tanks are standard on the Cascadia. Changing to a single 150-gallon tank reduces the vehicle's weight by 65 lbs. according to the 1/1/2020 Cascadia Databook. Logically, the lower the fuel capacity on board the vehicle, the greater the weight savings. However, as with all options, this specification must be application appropriate.

- **5th Wheel Slider Length** – Reducing slider length from 36" to a 24" or even a fixed 5th Wheel (which many weight sensitive applications use today) can assist in achieving enhanced lift time from OPTIMAAX. The software that controls the axle references the forward position of the slider in its calculations, so placing the 5th Wheel further toward the rear of the vehicle reduces the opportunity for overloading the steer axle.

- **Other** – Considering specifying lighter weight versions of all components so that truck specification can be optimized to reduce the weight of your tractor.

The calculator considers the vehicle configuration in conjunction with the trailer configuration and cargo type to optimize weight distribution through fine tuning the specification to allow OPTIMAAX to deliver the maximum benefit. Features can be selected from a pre-populated pull-down menu of options identified from the OEM databook to help calculate the estimated thresholds at which the system will retract and deploy. By using the calculator, it can be easily predicted which vehicle specifications may positively or negatively affect the deploy threshold and what changes could be made to help enhance OPTIMAAX operating efficiency or if an exact tractor/trailer combination are or are not viable candidates for the system. Hendrickson's Field Sales Team is equipped with this tool only as an aid to assist fleets and dealers in identifying opportunities to get the most benefit from the OPTIMAAX system.

Tractor Load	Steer Axle	Forward Tandem	Rear Tandem
Bobtail	10,500	0 lbs.	6,000 lbs.
Partial Load	12,500 lbs.	0 lbs.	15,500 lbs.
Full Load	12,000 lbs.	17,000 lbs.	17,000 lbs.

Tractor Load	Steer Axle	Forward Tandem	Rear Tandem
Bobtail	10,500	0 lbs.	6,000 lbs.
Partial Load	13,300 lbs.	0 lbs.	20,000 lbs.
Full Load	12,000 lbs.	17,000 lbs.	17,000 lbs.

Service

OPTIMAAX® is specifically designed and programmed to operate with the Freightliner Cascadia. Any technical concerns with the system should be taken to an Authorized Freightliner Service Dealer which has the trained personnel and the equipment needed to work on the system should technical issues arise.

For these Authorized Service Technicians, Hendrickson provides multiple resources.

OPTIMAAX is a system composed of two primary elements:

1. **The OPTIMAAX Liftable Forward Tandem Axle and Suspension System**
2. **The OPTIMAAX Lift Axle System Air Controller Module**

Each of these has its own Technical Publication and Parts List available on the Hendrickson website. These publications contain recommended service, maintenance, and system diagnosis instructions as well as a complete parts list of components.

In addition to these publications, Hendrickson has a staff of knowledgeable Technical Service Personnel available to assist with questions or concerns.

www.hendrickson-intl.com
855-RIDE RED (855-743-3733)
630-910-2800

Additional Resources

Hendrickson / OPTIMAAX Website:
www.OPTIMAAX.com

- Sales Literature
- Parts List
- Technical Publications
- Promotional Videos
- Regional Lift Axle Compliance Guide
- ROI Calculator

Driver Training Video:
www.youtube.com/watch?v=EtADjvcNsSs&feature=emb_rel_end

Glossary of Terms

6×2 – A three-axle tractor with power going to just one of the tandem rear axles.

6×4 – A three-axle tractor with power going to both of the tandem rear axles.

Anti-Lock Braking Systems (ABS) – A safety anti-skid braking system. ABS operates by preventing the wheels from locking up during braking, thereby maintaining tractive contact with the road surface.

Automatic Traction Control (ATC) – A secondary function of the electronic stability control (ESC) on production motor vehicles, designed to prevent loss of traction of driven road wheels. TCS is activated when throttle input and engine torque are mismatched to road surface conditions.

Axle Load / Deploy Threshold – The weight capacity threshold programmed into the OPTIMAAX® Electronic Control Unit (ECU) which is set as the trigger point to either deploy (lower) or raise the liftable axle.

Bobtail – A tractor without semi-trailers.

CAN Signal – Controller Area Network signal is a data signal transmitted between devices.

Driven Axle – An axle that is driven by the engine or prime mover.

Electronic Control Unit (ECU) – A device responsible for overseeing, regulating and altering the operation of a vehicle's electronic systems.

Green House Gas (GHG) – Any gas that has the property of absorbing infrared radiation (net heat energy) emitted from Earth's surface and reradiating it back to Earth's surface, thus contributing to the greenhouse effect. Carbon dioxide, methane, and water vapor are the most important greenhouse gases.

Gross Axle Weight Rating (GAWR) – The maximum distributed weight that may be supported by an axle of a road vehicle.

Gross Vehicle Weight Rating (GVWR) – The maximum operating weight/mass of a vehicle as specified by the manufacturer including the vehicle's chassis, body, engine, engine fluids, fuel, accessories, driver, passengers and cargo but excluding that of any trailers.

Liftable Axle – An axle that is not driven by the engine or prime mover but provides load bearing capacity for a tractor, and which can be lifted from or lowered (deployed) to the ground.

Load Bias – The distribution of air in a tandem axle air suspension allowing more or less weight or load to be transferred to or from the axle.

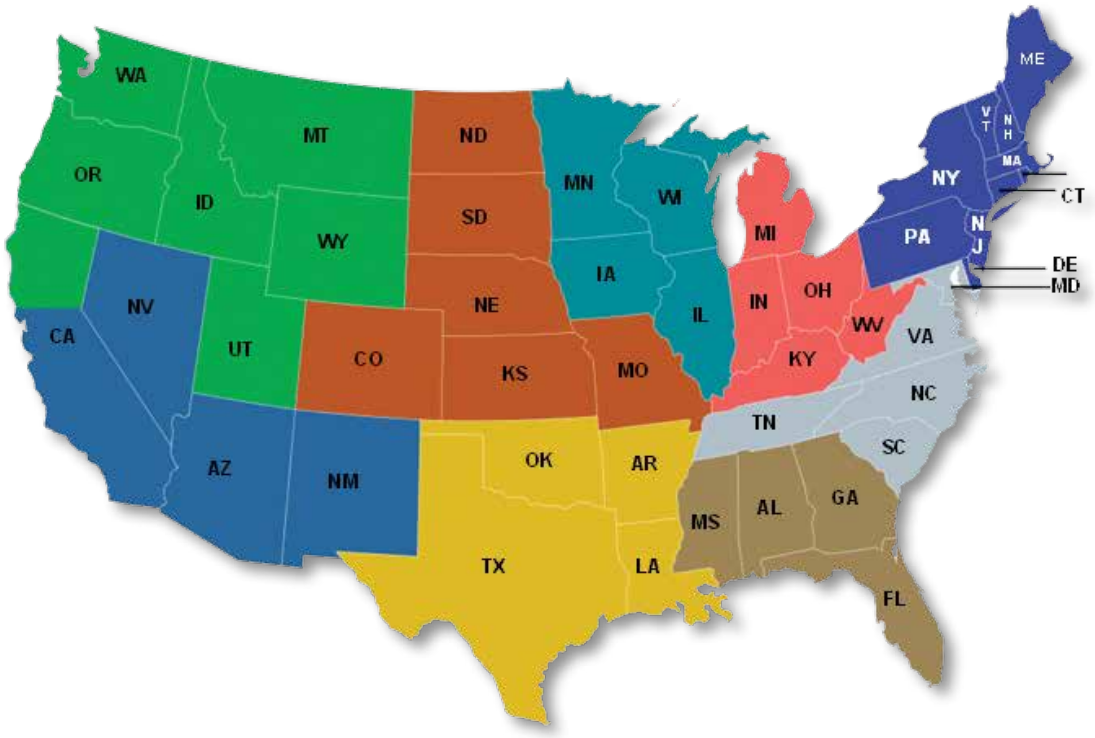
Tag Axle – A third axle located behind the rear drive axle of a vehicle. It is a non-drive axle with one or two tires on each side. The main purpose of a tag axle is to increase the support of the chassis at the rear of the vehicle, allowing for greater carrying capacity.

Tire Scrub – The condition of the tire on a vehicle physically sliding laterally when the wheels are turned and occurs when the tire does not turn on its centerline (it scrubs the road in a turn).

Torque Reaction – The reaction that occurs when a driven axle revolves in one direction which causes an equal force to transfer weight in the opposite direction.

Wheel Slip – Tire spinning that occurs when the force applied to a tire exceeds the traction available to that tire.

Hendrickson Sales Contacts



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Actual product performance may vary depending upon vehicle configuration, operation, service and other factors.
All applications must comply with applicable Hendrickson specifications and must be approved by
the respective vehicle manufacturer with the vehicle in its original, as-built configuration.
Contact Hendrickson for additional details regarding specifications, applications, capacities, and operation, service and maintenance instructions.

HENDRICKSON
Truck Commercial Vehicle Systems

ABOUT HENDRICKSON

Hendrickson, a Boler company, is a leading global manufacturer and supplier of medium- and heavy-duty mechanical, elastomeric and air suspensions; integrated and non-integrated axle and brakes systems; tire pressure control systems; auxiliary lift axles systems; parabolic and multi-leaf springs; stabilizers; bumpers; and components to the global commercial transportation industry. Hendrickson, based in Itasca, Ill., USA, continues to meet the needs of the transportation industry for more than 100 years. Visit Hendrickson at www.hendrickson-intl.com.

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