Bendix® ABS-6 Advanced with ESP® Stability System

Frequently Asked Questions to Help You Make an Intelligent Investment in Stability

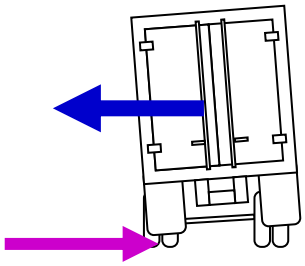
Contents:

Please note: This document is designed to assist you in the stability system decision process, not to serve as a performance guarantee. No system will prevent 100% of the incidents you may experience. This information is subject to change without notice

Key FAQs

What is roll stability?

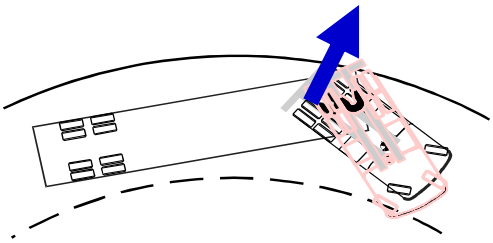
Roll stability counteracts the tendency of a vehicle, or vehicle combination, to tip over while changing direction (typically while turning). The lateral (side) acceleration creates a force at the center of gravity (CG), "pushing" the truck/tractor-trailer horizontally. The friction between the tires and the road opposes that force. If the lateral force is high enough, one side of the vehicle may begin to lift off the ground potentially causing the vehicle to roll over. Factors influencing the sensitivity of a vehicle to lateral forces include: the load CG height, load offset, road adhesion, suspension stiffness, frame stiffness and track width of vehicle.



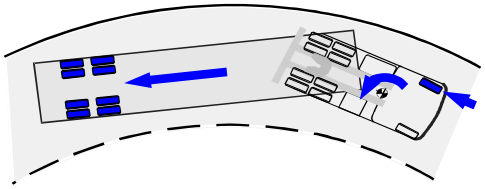
What is yaw stability?

Yaw stability counteracts the tendency of a vehicle to spin about its vertical axis. During operation, if the friction between the road surface and the tractor's tires is not sufficient to oppose lateral (side) forces, one or more of the tires can slide, causing the truck/tractor to spin. These events are referred to either as an "under-steer" situation (where there is a lack of vehicle response to steering input due to tire slide on the steer axle) or an "over-steer" situation (where the tractor's rear end slides out due to tire slide on the rear axle). Generally, shorter wheelbase vehicles (tractors, for instance) have less natural yaw stability, while longer wheelbase vehicles (e.g. straight trucks) have greater natural yaw stability. Factors that influence yaw stability are: wheelbase, suspension, steering geometry, weight distribution front to rear, and vehicle tracking.

Over-steer situation *without intervention*



Over-steer situation *with intervention*



How does the Bendix® ESP® stability system work?

During operation, the electronic control unit (ECU) of the Bendix® ABS-6 Advanced with ESP® system constantly compares performance models to the vehicle's actual movement, using the wheel speed sensors of the ABS system, as well as lateral, yaw, and steering angle sensors. If the vehicle shows a tendency to leave an appropriate travel path, or if critical threshold values are approached, the system will intervene to assist the driver.

In the case of a potential roll event, the system will override the throttle and quickly apply brake pressure at selected wheel ends to slow the vehicle below a critical threshold. In the case of vehicle slide ("over-steer" or "under-steer" situations), the system will reduce the throttle and then brake one or more of the "four corners" of the vehicle (in addition to potentially applying trailer brakes), thus applying a counter-force to better align the vehicle with an appropriate path of travel. For example, in an "over-steer" situation, the system applies the "outside" front brake; while in an under-steer condition, the inside rear brake is applied.

How does the Bendix® ESP® system differ from MeritorWABCO® RSC (Roll Stability Control)?

The charts below summarize the key differences between the two systems. Additional detail about some of these key differences is also contained in the questions and answers following the chart.

Driving Scenario Coverage

Dry Surface Coverage: To sense and respond to a potential rollover risk on a dry surface the stability system must be able to sense lateral forces acting on the vehicle and apply brakes to reduce the vehicle's speed.

Both the WABCO® RSC system and the Bendix® ESP® system have these capabilities. However, the Bendix ESP system can identify a rollover risk earlier by using a steer angle sensor and load sensor to calculate the lateral forces before they actually occur. Additionally, because the Bendix ESP system can apply braking at all available axles it is more effective at reducing the vehicle's speed and therefore reducing the rollover risk.

Slippery Surfaces and Surface Transitions: For a stability system to sense and respond to stability events such as under-steer, over-steer, or jackknife on slippery surfaces or surface transitions (such as patchy ice or gravel shoulder), the system must be able to sense both the steer-angle and the yaw (spin) rate of the vehicle and apply brakes at individual wheel ends.

The Bendix ESP system is equipped with a steering angle sensor, a yaw rate sensor, and has the ability to brake individual wheel ends while the WABCO RSC system does not have a steer angle sensor, a yaw rate sensor or the capability to apply brakes at individual wheel ends.

		Stability System Features which Enable or Improve Response to a Stability risk situation						
Driving Surface / Condition	Potential Stability Risk	Lateral Acceleration Sensor	Load Sensor	Brake Pressure Sensor	Steering Angle Sensor	Yaw Rate Sensor	All Axle Braking	Individual Wheel End Braking
Dry Surfaces (Concrete, dry asphalt)	Rollover	✓	✓	✓	✓	✓	✓	✓
Slippery Surfaces (Wet asphalt, packed snow, ice)	Under-steer Over-steer Jackknife Loss of control		✓	✓	✓	✓	✓	✓
Surface Transitions (Patchy ice, gravel shoulder)	Jackknife Loss of control		✓	✓	✓	✓	✓	✓

Features supported by both WABCO® RSC and Bendix® ABS-6 Advanced with ESP®

Features supported only by Bendix® ABS-6 Advanced with ESP®

Key features

	Feature	What it does	Why it matters	*Wabco® RSC*	*Bendix® ABS-6 Advanced with ESP®*
	Available in 4S/4M, 6S/4M, and 6S/6M ABS	Available on different ABS / ATC configurations	Adaptable for the needs of various fleet specific vehicles	✓	✓
Bendix® ESP Sensor Technology	Wheel Speed Sensor	Monitors the wheel rotation at individual wheels	Allows the system to determine vehicle speed and monitor wheel lock-up to optimize braking	✓	✓
	Lateral Acceleration Sensor	Senses the side or lateral forces acting on the vehicle	Side or lateral forces are used to detect a roll situation	✓	✓
	Steering Angle Sensor	Senses the driver's steering demand and direction	An early indicator of a potential critical maneuver. Helps the system respond faster and more accurately.		✓
	Brake Pressure Sensors	Measures the driver's braking demand	Allows the system to accurately supplement the driver throughout the maneuver		✓
	Load Sensor	Senses the vehicle's load situation.	Allows for the system to match braking power to weight distribution		✓

	Yaw Rate Sensor	Senses the rotation of the vehicle	Allows the system to monitor the true orientation of the vehicle and compare it to an appropriate path of travel		✓
Bendix® ESP Performance Enhancements	Multi-level Sensing	Cross checks multiple system sensors	Improves the reaction time and accuracy of the intervention		✓
	Tuning	Different trucks or towing vehicles have different stability characteristics. Tuning allows the stability system to account for these differences.	Improves the ability of the stability system to match the intervention to the situation		✓
	All Axle Braking	The ability to apply brakes at all axles	Provides the best opportunity to reduce vehicle speed in the shortest time		✓
	Individual Corner Braking	The ability to apply individual and trailer brakes	Provides the capability to mitigate under and over-steer situations		✓

How does Bendix® ABS-6 Advanced with ESP performance differ from the MeritorWABCO® RSC?

Mitigating rollovers is a combination of two primary factors:

- *The amount of braking power applied to reduce vehicle speed, thus improving the stability margin.*
  - The ESP feature of the Bendix ABS-6 Advanced system *can apply all brakes available on the vehicle* – trailer, drive and steer axle. Bendix ESP is also capable of applying full pressure to all axles, if appropriate.
  - MeritorWABCO RSC does not apply the steer axle brakes and only partially applies tandem and trailer brakes.
- *The time between the start of a maneuver and the point at which the brakes are applied.* This factor is crucial to the ability of any stability system to effectively mitigate a rollover.

  - The Bendix® ESP® system utilizes a steering angle sensor that detects the initial change in vehicle direction from the driver's steering input and calculates the lateral force that will result. As a vehicle proceeds through a maneuver, the lateral acceleration progressively increases up to a critical threshold. If the system senses the curve becoming tighter due to the steering angle, the brakes are automatically applied by the system before the critical threshold is exceeded. Early detection with the steering angle sensor and correlation of the initial indication from a lateral accelerometer enable the Bendix ESP system to react quicker. Earlier detection/reaction and the amount of braking power available could be the difference between "recovery" and "roll." Additional details on the importance of these factors are covered in the Function/Performance section of this document.

  - In vehicles without a steering angle sensor, there can be up to a 1 second delay in system intervention to ensure the lateral acceleration is not caused by a "bump in the road" or other false event.

If I don't drive on ice, will roll stability be enough?

Not necessarily. Even if you don't regularly drive on ice or snow, you most likely do encounter medium-friction surfaces such as gravel, sand, wet pavement or combinations of these surfaces. A roll-only system will not activate when a vehicle is sliding – something that can easily happen on any of these medium-friction surfaces. A roll-only stability system would only intervene when a high lateral force is detected (transitioning onto dry pavement, for example) but by then it may be too late to prevent a rollover.

Any time you have an understeer or oversteer condition, such as when part of the vehicle is on a soft shoulder, you lose directional control. A rollover-only system cannot help the vehicle to regain control in this situation. Bendix ESP, however, can assist the driver in regaining directional control.

Why does a straight truck need the Bendix ESP System?

It is true since a straight truck is a single unit vehicle you won't have jackknife conditions. However, loss of directional control (such as under-steer or over-steer) can also pose a problem. So along with rollover mitigation, you need to enable a driver to maintain directional control of his/her vehicle in order to mitigate secondary rollover events – such as soft shoulder pulling the vehicle into a ditch and resulting in a rollover.

Will the Bendix® ABS-6 Advanced with ESP® system prevent my fleet from having any rollovers, jackknifes or out-of-control situations?

No stability system can prevent every conceivable incident. Nor can any stability system overrule the laws of physics. For example, if a driver tries to take a turn at 70 mph when a "safe" speed (as posted) for that maneuver is only 30 mph, the stability system must reduce vehicle speed before it could eliminate a potential rollover. But, even if the system applied the brakes at full pressure, it still may not be possible to reduce the vehicle's speed to a safe level in time to avoid a rollover. Similar physical limits exist in yaw interventions where road-tire adhesion limits provide only so much force for compensation. Stability systems that can react sooner and help apply the greatest amount of available braking force offer the greatest potential for mitigating incidents.

Because of the ESP functionality, does the Bendix ESP stability system require special maintenance?

By utilizing the North American pneumatic brake system as a base, the core components (wheel speed sensors, modulators, traction, relays and ECU's) remain essentially the same. Your current service procedures for the core components will remain substantially the same. The additional ESP system components (yaw rate / lateral accelerometer, steering angle and pressure sensors) are based on proven technology with millions of miles in use. These components will require special attention in certain maintenance procedures described below. Their replacement is limited to direct part replacement. In addition, the diagnostic tools offered by Bendix have been enhanced to support the expanded functionality of ESP systems using the same friendly interface for the technician.

Two areas where Bendix ESP sensors require special attention, include:

1. ***Front end alignment or work*** – Anytime the vehicle has a front-end alignment or work that involves the steering system, the Steering Angle Sensors (SAS-60) of the Bendix ESP stability system needs to be recalibrated to zero. Recalibration of the sensor involves following the procedures noted described in Bendix Service Data Sheet – SD-13-4869 "*Bendix® EC-60™ ABS/ATC/ESP Controllers (Advanced Models)"* and using ACom Diagnostic Software (version 5.3 or later).
2. ***If the Yaw Rate Sensor*** (YRS-60) is removed for service from where it is attached, it must be replaced in the exact same location and exact same orientation using the same mounting bracket. Recalibration of the sensor involves following the procedures described in Bendix Service Data Sheet – SD-13-4869 "*Bendix® EC-60™ ABS/ATC/ESP Controllers (Advanced Models)"* and using ACom Diagnostic Software (version 5.3 or later). Note: the Yaw Rate Sensor cannot be relocated to another part of the chassis. Moving this sensor may cause inappropriate interventions by the Bendix ESP system.

Is the Bendix® ABS-6 Advanced system with ESP® available for retrofit on my existing vehicles?

No. Retrofit is not a viable option because of the requirement for system validation on the vehicle by the OEM and Bendix before on-road operation. All systems are OE installed and validated at the factory. In addition, the cost and complexity to retrofit an existing vehicle, makes that option impractical.

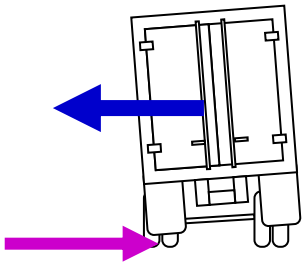
Will a stability system encourage my drivers to drive more aggressively?

It should not. The Bendix® ABS-6 Advanced with ESP® stability system was designed to supplement safe driving practices, and is not intended to enable or encourage drivers to drive more aggressively. The system actively discourages aggressive driving by reducing vehicle speed after a system intervention to a level that is below the critical stability threshold.

Stability Definitions

What is roll stability?

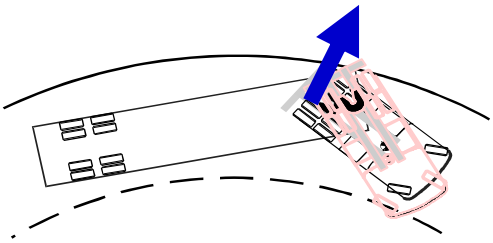
Roll stability counteracts the tendency of a vehicle, or vehicle combination, to tip over while changing direction (typically while turning). The lateral (side) acceleration creates a force at the center of gravity (CG), "pushing" the truck/tractor-trailer horizontally. The friction between the tires and the road opposes that force. If the lateral force is high enough, one side of the vehicle may begin to lift off the ground potentially causing the vehicle to roll over. Factors influencing the sensitivity of a vehicle to lateral forces include: the load CG height, load offset, road adhesion, suspension stiffness, frame stiffness and track width of vehicle.



What is yaw stability?

Yaw stability counteracts the tendency of a vehicle to spin about its vertical axis. During operation, if the friction between the road surface and the tractor's tires is not sufficient to oppose lateral (side) forces, one or more of the tires can slide, causing the truck/tractor to spin. These events are referred to either as an "under-steer" situation (where there is a lack of vehicle response to steering input due to tire slide on the steer axle) or an "over-steer" situation (where the tractor's rear end slides out due to tire slide on the rear axle). Generally, shorter wheelbase vehicles (tractors, for instance) have less natural yaw stability, while longer wheelbase vehicles (e.g. straight trucks) have greater natural yaw stability. Factors that influence yaw stability are: wheelbase, suspension, steering geometry, weight distribution front to rear, and vehicle tracking.

Over-steer situation *without intervention*



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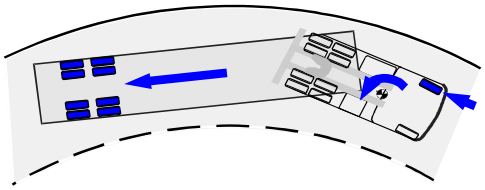

How does the Bendix® ESP® stability system work?

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In the case of a potential roll event, the system will override the throttle and quickly apply brake pressure at selected wheel ends to slow the vehicle below a critical threshold. In the case of vehicle slide ("over-steer" or "under-steer" situations), the system will reduce the throttle and then brake one or more of the "four corners" of the vehicle (in addition to potentially applying trailer brakes), thus applying a counter-force to better align the vehicle with an appropriate path of travel. For example, in an "over-steer" situation, the system applies the "outside" front brake; while in an under-steer condition, the inside rear brake is applied.

How does the Bendix® ESP® system differ from MeritorWABCO® RSC (Roll Stability Control)?

The charts below summarize the key differences between the two systems. Additional detail about some of these key differences is also contained in the questions and answers following the chart.

Driving Scenario Coverage

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Both the WABCO® RSC system and the Bendix® ESP® system have these capabilities. However, the Bendix ESP system can identify a rollover risk earlier by using a steer angle sensor and load sensor to calculate the lateral forces before they actually occur. Additionally, because the Bendix ESP system can apply braking at all available axles it is more effective at reducing the vehicle's speed and therefore reducing the rollover risk.

Slippery Surfaces and Surface Transitions: For a stability system to sense and respond to stability events such as under-steer, over-steer, or jackknife on slippery surfaces or surface transitions (such as patchy ice or gravel shoulder), the system must be able to sense both the steer-angle and the yaw (spin) rate of the vehicle and apply brakes at individual wheel ends.

The Bendix ESP system is equipped with a steering angle sensor, a yaw rate sensor, and has the ability to brake individual wheel ends while the WABCO RSC system does not have a steer angle sensor, a yaw rate sensor or the capability to apply brakes at individual wheel ends.

		Stability System Features which Enable or Improve Response to a Stability risk situation						
Driving Surface / Condition	Potential Stability Risk	Lateral Acceleration Sensor	Load Sensor	Brake Pressure Sensor	Steering Angle Sensor	Yaw Rate Sensor	All Axle Braking	Individual Wheel End Braking
Dry Surfaces (Concrete, dry asphalt)	Rollover	✓	✓	✓	✓	✓	✓	✓
Slippery Surfaces (Wet asphalt, packed snow, ice)	Under-steer Over-steer Jackknife Loss of control		✓	✓	✓	✓	✓	✓
Surface Transitions (Patchy ice, gravel shoulder)	Jackknife Loss of control		✓	✓	✓	✓	✓	✓

Features supported by both WABCO® RSC and Bendix® ABS-6 Advanced with ESP®

Features supported only by Bendix® ABS-6 Advanced with ESP®

Key features

	Feature	What it does	Why it matters	*Wabco® RSC*	*Bendix® ABS-6 Advanced with ESP®*
	Available in 4S/4M, 6S/4M, and 6S/6M ABS	Available on different ABS / ATC configurations	Adaptable for the needs of various fleet specific vehicles	✓	✓
Bendix® ESP Sensor Technology	Wheel Speed Sensor	Monitors the wheel rotation at individual wheels	Allows the system to determine vehicle speed and monitor wheel lock-up to optimize braking	✓	✓
	Lateral Acceleration Sensor	Senses the side or lateral forces acting on the vehicle	Side or lateral forces are used to detect a roll situation	✓	✓
	Steering Angle Sensor	Senses the driver's steering demand and direction	An early indicator of a potential critical maneuver. Helps the system respond faster and more accurately.		✓
	Brake Pressure Sensors	Measures the driver's braking demand	Allows the system to accurately supplement the driver throughout the maneuver		✓
	Load Sensor	Senses the vehicle's load situation.	Allows for the system to match braking power to weight distribution		✓

	Yaw Rate Sensor	Senses the rotation of the vehicle	Allows the system to monitor the true orientation of the vehicle and compare it to an appropriate path of travel		✓
Bendix® ESP Performance Enhancements	Multi-level Sensing	Cross checks multiple system sensors	Improves the reaction time and accuracy of the intervention		✓
	Tuning	Different trucks or towing vehicles have different stability characteristics. Tuning allows the stability system to account for these differences.	Improves the ability of the stability system to match the intervention to the situation		✓
	All Axle Braking	The ability to apply brakes at all axles	Provides the best opportunity to reduce vehicle speed in the shortest time		✓
	Individual Corner Braking	The ability to apply individual and trailer brakes	Provides the capability to mitigate under and over-steer situations		✓

How does Bendix® ABS-6 Advanced with ESP performance differ from the MeritorWABCO® RSC?

Mitigating rollovers is a combination of two primary factors:

- *The amount of braking power applied to reduce vehicle speed, thus improving the stability margin.*
  - The ESP feature of the Bendix ABS-6 Advanced system *can apply all brakes available on the vehicle* – trailer, drive and steer axle. Bendix ESP is also capable of applying full pressure to all axles, if appropriate.
  - MeritorWABCO RSC does not apply the steer axle brakes and only partially applies tandem and trailer brakes.
- *The time between the start of a maneuver and the point at which the brakes are applied.* This factor is crucial to the ability of any stability system to effectively mitigate a rollover.

  - The Bendix® ESP® system utilizes a steering angle sensor that detects the initial change in vehicle direction from the driver's steering input and calculates the lateral force that will result. As a vehicle proceeds through a maneuver, the lateral acceleration progressively increases up to a critical threshold. If the system senses the curve becoming tighter due to the steering angle, the brakes are automatically applied by the system before the critical threshold is exceeded. Early detection with the steering angle sensor and correlation of the initial indication from a lateral accelerometer enable the Bendix ESP system to react quicker. Earlier detection/reaction and the amount of braking power available could be the difference between "recovery" and "roll." Additional details on the importance of these factors are covered in the Function/Performance section of this document.

  - In vehicles without a steering angle sensor, there can be up to a 1 second delay in system intervention to ensure the lateral acceleration is not caused by a "bump in the road" or other false event.

Function / Performance

What is the benefit of the steering angle sensor on the Bendix® ABS-6 Advanced system with ESP®?

The steering angle sensor enables the Bendix® ESP® stability system to capture information about the intended path of travel and intervene if a yaw correction is indicated. The sensor also provides the earliest indication of an increase in lateral acceleration leading to a potential roll event, resulting in a greater stability margin when a vehicle is equipped with a steering angle sensor.

Why are brake demand sensors necessary?

The Bendix ABS-6 Advanced stability system was designed around the idea of creating a system that supplements the driver. By directly measuring driver brake demand, the system can seamlessly transition between driver-intended and system-calculated optimal braking pressure. For example, if, during a certain maneuver, the system calculates that 40 psi is needed but the driver is only applying 20 psi, the system compensates automatically to deliver the needed 40 psi. If, however, during the same maneuver the driver steps on the brake pedal quickly to apply a higher braking level – say 60 psi – then 60 psi will be delivered.

A stability system *without* brake demand sensors needs to utilize indirect and therefore, less accurate methods to estimate if the driver is applying brake pressure. For example, a stability system without a brake demand sensor might try to correlate significant wheel slip at the front axle to driver brake demand. When significant wheel slip is occurs, the stability system may not activate and give full braking control to the driver. Because this approach relies on an estimation of wheel slip, it can be fooled, causing a potentially undesirable result.

Here are two examples of situations that could be encountered by a vehicle that is *not* equipped with brake demand sensors.

> ***Example 1:***
> *The driver unintentionally shuts the system off when stability assistance is needed*
>
> The vehicle enters a curve too fast, causing the stability system to intervene and begin a brake application. The driver feels the brakes being applied by the stability system and reacts by applying the brakes himself, causing the front axle wheels to slip, which triggers the stability system to not activate. In response, the driver then reduces braking substantially. But, if the risk of a rollover still exists, the system will be unable to detect that brake pressure has dropped below the necessary level, and a rollover could still occur.
>
> ***Example 2:***
> *The driver cannot take over braking demand immediately.*
>
> The vehicle enters a curve too fast. The stability system intervenes with partial brake applications, but circumstances (such as an obstacle in front of the vehicle) cause the driver to demand faster deceleration than the system is providing at the time. The driver applies the brakes, but because the system does not estimate significant slip at the front wheels, he cannot override the system to increase braking pressure to all available axles. Although a potential rollover may be avoided, vehicle safety could be compromised because the driver was unable to apply all available braking when it was required.

Our Bendix® ABS-6 Advanced with ESP® system utilizes redundant pressure sensors that can more effectively mitigate the risks described in both situations. However, the laws of physics still apply, and there are potential loss of control scenarios that are beyond the capability of *any* currently available stability system.

What is the primary function of steer axle brakes in the Bendix ESP stability system?

There are four primary reasons that can dictate the need for steer axle brakes.

First, a weight transfer to the front of the vehicle occurs dynamically during brake application. In roll events, the critical element is the ability to slow the vehicle as quickly as possible. Steer axle brakes add considerably to the available braking capacity. This is especially true for straight trucks where braking distribution to the steer axle may represent a larger percentage of a vehicle's overall braking capability.

Next, during high-speed maneuvers in potential rollover situations, the tandem tires of the tractor and trailer, or the drive axle on straight trucks, can lift off the ground. If that occurs, the steer axle brakes provide a much larger percentage of available braking capacity because wheels that are no longer in contact with the road surface are incapable of providing any braking force.

Third, the ability to apply steer axle brakes individually is a fundamental requirement for yaw (spin) control. By applying brakes at any one or all of a vehicle's "four corners," the stability system may be able to correct the vehicle's orientation, mitigating the potential for a jackknife, spin out or slide.

Finally, with potential regulatory requirements for larger front brakes in the future, the steer axle's contribution to a vehicle's overall braking capacity and potential stability margin is expected to increase.

If the stability system applies full brakes, will the wheels lock up?

No. With Bendix® ABS-6 Advanced, the ABS system is given "priority" at the wheel ends to manage wheel slip for optimal braking. The ABS system will function similarly whether the stability system or the driver applies the brakes.

If I don't drive on ice, will roll stability be enough?

Not necessarily. Even if you don't regularly drive on ice or snow, you most likely do encounter medium-friction surfaces such as gravel, sand, wet pavement or combinations of these surfaces. A roll-only system will not activate when a vehicle is sliding – something that can easily happen on any of these medium-friction surfaces. A roll-only stability system would only intervene when a high lateral force is detected (transitioning onto dry pavement, for example) but by then it may be too late to prevent a rollover.

Any time you have an under-steer or over-steer condition, such as when part of the vehicle is on a soft shoulder, you lose directional control. A rollover-only system cannot help the vehicle to regain control in this situation. Bendix ESP, however, can assist the driver in regaining directional control.

What is the difference with Bendix "performance tuning" the system to the vehicle vs. having a simple generic application?

Overall vehicle dynamics are based on a multitude of variables including weight, Center of Gravity (CG) location, wheel base, suspension stiffness, and more. A vehicle that has a short wheel base will react differently than a vehicle with a long wheel base. Bendix® ABS-6 with ESP® is pre-programmed with a model of your vehicle and its influencing dynamic factors (suspension, wheel base, brake torque, etc). With this model, the stability system is better able to predict critical thresholds, the level of necessary intervention and changes in vehicle dynamics that will likely result from an intervention. This additional information enables more optimal interventions for a given driving scenario.

I have vehicles equipped with a stability control system running in my fleet. Can I specify or change the system's intervention parameters?

No. The system's stability structure is uniformly determined by the OEM and Bendix based on a number of variables for each vehicle model.

Can I activate or deactivate or fine-tune the performance of the Bendix®ESP® system as necessary?

No. The system is optimized to perform with the specific vehicle configuration.

Why does a straight truck need the Bendix ESP System?

It is true since a straight truck is a single unit vehicle you won't have jackknife conditions. However, loss of directional control (such as under-steer or over-steer) can also pose a problem. So along with rollover mitigation, you need to enable a driver to maintain directional control of his/her vehicle in order to mitigate secondary rollover events – such as soft shoulder pulling the vehicle into a ditch and resulting in a rollover.

Does the Bendix ESP system override the engine throttle?

Yes. The system is designed to help supplement the driver, and mitigate the instability risk by reducing engine torque as a first step.

In the case of a potential rollover risk, the system will reduce engine torque and quickly apply brake pressure at the appropriate wheels to slow the vehicle to a speed below the critical threshold value. In the case of vehicle slide ("over-steer" or "under-steer" situations), the system will reduce engine torque and then brake one or more of the "four corners" of the vehicle (in addition to potentially braking the trailer), thus applying a countering rotational moment to better align the vehicle with an appropriate path of travel.

I have a vehicle with automatic transmission. Will the Bendix ESP stability system still work?

Yes. The type of transmissions in your vehicle has no significant impact on the functionality of the Bendix ESP stability system.

Will a manual transmission have any impact on the performance level of the Bendix ESP stability system?

No. The type of transmissions in your vehicle has no significant impact on the functionality of the Bendix stability system.

Value

Does Bendix® ABS-6 Advanced with ESP® system deliver a higher value?

Yes. Value was one of the essential criteria considered when developing this commercial vehicle system. The Bendix® ABS-6 Advanced with ESP® system is designed to make appropriate interventions in the widest possible range of scenarios. This led to the addition of sensors that collect critical data to provide multiple data points to cross check system calculations. Our focus during the comprehensive development process was to deliver a cost effective system without compromising scope, integrity or performance. The Bendix ESP system includes an array of sensors and delivers unmatched ABS-based vehicle stability performance, thus achieving the highest overall value for fleets and end users. Statistics show that ESP can provide more mitigation capability across a wider range of driving conditions than roll only systems. Considering the total cost of the system is typically less than 2% total vehicle cost, the additional money provides the widest range of benefit.

Will the Bendix® ABS-6 Advanced with ESP® system prevent my fleet from having any rollovers, jackknifes or out-of-control situations?

No stability system can prevent every conceivable incident. Nor can any stability system overrule the laws of physics. For example, if a driver tries to take a turn at 70 mph when a "safe" speed (as posted) for that maneuver is only 30 mph, the stability system must reduce vehicle speed before it could eliminate a potential rollover. But, even if the system applied the brakes at full pressure, it still may not be possible to reduce the vehicle's speed to a safe level in time to avoid a rollover. Similar physical limits exist in yaw interventions where road-tire adhesion limits provide only so much force for compensation. Stability systems that can react sooner and help apply the greatest amount of available braking force offer the greatest potential for mitigating incidents.

What is the reduction in incidents that I can expect to see from a stability system?

The reduction in incidents depends on the factors that are causing your current experience such as: driver experience level, familiarity with and difficulty of the routes driven, driving conditions, traffic conditions, driver distractions, vehicle maintenance levels and many other elements.

I have relatively few jackknifes, but do have rollovers-why should I buy the Bendix® ESP® stability system?

Bendix has identified many tractor-trailer and straight truck driving scenarios in which a roll-only stability system would not have been effective in avoiding a rollover incident. A full stability system with both yaw and roll capability, however, may have helped avoid the incident completely.

Here's an example: A driver is distracted, contributing to an off-course situation where the driver then over corrects his vehicle. The tractor over-steers, causing a jackknife, during which the vehicle enters a ditch, resulting in a rollover. In this case the rollover was a *secondary* event resulting from the *primary* problem – loss of lateral stability or "over-steer." Bendix® ABS-6 Advanced with the ESP® system would have helped and may have avoided the wreck. In comparison, a roll-only system would have had little or no effect.

We encourage fleets to perform an in-depth analysis of their fleet incidents to evaluate the root cause and potential benefit of the stability systems available. To assist in that effort, we have prepared a comprehensive analytical tool to help you identify and evaluate all of the potential elements in your unique situation. Once you complete the analysis, we believe you will recognize the clear benefits our approach offers to the entire "stability control" issue.

I've been told it would be cheaper to install a trailer roll stability system (TRSP) instead of a tractor system. What is the difference?

The performance of a trailer-only stability system is inherently less than that of a tractor-based system because the trailer system cannot control both the tractor and trailer brakes, while a tractor-based system can control both vehicles.

Consider this example: rollover events typically are initiated by steering inputs. Several seconds may elapse before the lateral acceleration increases to the extent that it will be detected by a sensor located on the trailer. The resulting delay reduces the potential for a trailer-based system to mitigate a rollover event.

Trailer stability systems are rollover-only systems and cannot address the directional or yaw control situations. Keep in mind that tractors equipped with the Bendix ESP system also control the trailer brakes during an intervention. A trailer stability system only controls the brakes on the trailer.

Two additional factors that must be considered when evaluating trailer-only versus tractor systems are your ratio of tractors to trailers, and the rate at which you replace or exchange tractors vs. trailers.

Because of the ESP functionality, does the Bendix ESP stability system require special maintenance?

By utilizing the North American pneumatic brake system as a base, the core components (wheel speed sensors, modulators, traction, relays and ECU's) remain essentially the same. Your current service procedures for the core components will remain substantially the same. The additional ESP system components (yaw rate / lateral accelerometer, steering angle and pressure sensors) are based on proven technology with millions of miles in use. These components will require special attention in certain maintenance procedures described below. Their replacement is limited to direct part replacement. In addition, the diagnostic tools offered by Bendix have been enhanced to support the expanded functionality of ESP systems using the same friendly interface for the technician.

Two areas where Bendix ESP sensors require special attention, include:

3. ***Front end alignment or work*** – Anytime the vehicle has a front-end alignment or work that involves the steering system, the Steering Angle Sensors (SAS-60) of the Bendix ESP stability system needs to be recalibrated to zero. Recalibration of the sensor involves following the procedures noted described in Bendix Service Data Sheet – SD-13-4869 "*Bendix® EC-60™ ABS/ATC/ESP Controllers (Advanced Models)"* and using ACom Diagnostic Software (version 5.3 or later).
4. ***If the Yaw Rate Sensor*** (YRS-60) is removed for service from where it is attached, it must be replaced in the exact same location and exact same orientation using the same mounting bracket. Recalibration of the sensor involves following the procedures described in Bendix Service Data Sheet – SD-13-4869 "*Bendix® EC-60™ ABS/ATC/ESP Controllers (Advanced Models)"* and using ACom Diagnostic Software (version 5.3 or later). Note: the Yaw Rate Sensor cannot be relocated to another part of the chassis. Moving this sensor may cause inappropriate interventions by the Bendix ESP system.

Is traction control included in the Bendix® ABS-6 Advanced with ESP® stability system, or is there additional cost to have it available on my vehicle?

The comprehensive Bendix® ABS-6 Advanced with ESP® system delivers a cost effective system without compromising scope, integrity or performance to fleets and end users. Therefore the system includes:

- *Automatic Traction Control* (ATC);
- *Auxiliary Design Language* (ADL) – the patent-pending customization feature that enables customer specific features for your fleet;
- *Roll stability and Yaw stability* – the two primary elements that comprise the complete Bendix ESP system.

Availability/Applications

Is the Bendix® ABS-6 Advanced with ESP® stability system available today?

Yes. The Bendix® ABS-6 Advanced with ESP® stability system is available on a variety of Kenworth, Peterbilt, Mack, Volvo and International highway models/configurations and for select vocational applications. International also offers a rollover only system - Bendix ABS-6 Advanced with RSP (Roll Stability Program).

Bendix ESP is now standard on Mack and Volvo highway tractors.

Is the Bendix ABS-6 Advanced with ESP stability system available on vocational applications?

The Bendix ABS-6 Advanced with ESP stability system is available on OE vocational vehicles. Check with your OE dealer to determine if the system is available on the vocational model/configuration of interest to you.

Is the Bendix ABS-6 Advanced with ESP stability system available on Coach/Bus applications?

The Bendix® ABS-6 Advanced with ESP® is available on coach/bus applications. A bus manufacturer, Prevost announced availability of the Bendix ESP system in early 2007. Other coach/bus manufacturers are also looking at including the Bendix ESP stability system on their vehicles.

What if my trailer does not have ABS?

No problem. The Bendix® ABS-6 Advanced system with ESP® works equally well whether or not a trailer is equipped with ABS. To reduce the incidence of trailer wheel-end lock-up, the system simulates ABS by pulsating the braking pressure delivered to the trailer. ***Please note:*** *If a trailer is not equipped with ABS, however, the driver can still lock-up the trailer brakes through driver brake application.*

Can I use Bendix ABS-6 Advanced with ESP on doubles/triples?

Yes. Bendix has validated the functionality of its ABS-6 Advanced with ESP® for use on semi-tractors with multiple trailer combinations. (C-Trains, B-trains, A-trains, converter dollies, etc.)

Can I use the same tractor with Bendix ABS-6 Advanced with ESP to pull single and multiple trailers?

Yes. The same Bendix ABS-6 Advanced with ESP system installed on tractors will work with single or multiple trailers and requires no adjustment to the system. This provides additional flexibility to fleets and owner/operators who pull different trailer combinations.

Is Bendix ESP compatible on trailers or dollies with an ABS system that is not Bendix?

Yes. The Bendix system will function with any trailer or dolly braking system that is FMVS121 compliant.

Can I use Bendix ABS-6 Advanced with ESP® on straight trucks with a trailer?

Not at this time. Bendix has not yet validated ESP performance on straight-truck/trailer combinations.

Do I need a Trailer Roll Stability Program (TRSP) if I have ESP® on my tractors?

In many cases, TRSP will provide minimal additional benefits when used with the Bendix ABS-6 Advanced with ESP system. However, for fleets with few tractors and many trailers, and who use owner/operators along with their own drivers/tractors having both tractors and trailers with stability systems will improve the chances that vehicle combinations will have some degree of stability coverage.

Can I use the Bendix ABS-6 Advanced with ESP system on tankers or combinations with shifting loads?

Yes. But remember that an individual load's distribution and ability to shift will interact with the dynamic properties of a vehicle, impacting the tanker's overall stability margin. In specific driving maneuvers, sloshing liquid cargo or moving loads (e.g. cattle or hanging beef), can reduce the margins of optimal system performance as compared to vehicles having similar CG heights but carrying *fixed* loads. Fixed loads are inherently more stable than non-fixed or shifting loads. While the Bendix ESP stability system will provide stability enhancement with all trailer and load types, the laws of physics cannot be ignored or overcome. Every stability system must function within those limits.

I have an unbaffled tanker. Can the Bendix ABS-6 Advanced with ESP stability system handle the sloshing?

The system will improve the overall stability of the unbaffled tanker; however the performance level will be less than that of a comparable vehicle combination with a fixed load. It's important to remember that an individual load's distribution and ability to shift will interact with the dynamic properties of a vehicle, impacting the tanker's overall stability margin. In specific driving maneuvers, sloshing liquid cargo or moving loads (e.g. cattle or hanging beef), can reduce the margins of optimal system performance as compared to vehicles having similar CG heights but carrying *fixed* loads. The laws of physics cannot be ignored or overcome. Every stability system must function within those limits.

Vehicle System Integration

Is the Bendix® ABS-6 Advanced system with ESP® available for retrofit on my existing vehicles?

No. Retrofit is not a viable option because of the requirement for system validation on the vehicle by the OEM and Bendix before on-road operation. All systems are OE installed and validated at the factory. In addition, the cost and complexity to retrofit an existing vehicle, makes that option impractical.

Will the Bendix ABS-6 Advanced ESP system be effective with Air Disc Brakes?

Yes. The Bendix ABS-6 Advanced system with ESP works with all brake types and sizes. System performance is derived from the brake torque capacity at each wheel end. The ability to decelerate the vehicle is dependent on the amount of brake torque available ... the more that is available, the greater the stability margin you can expect for your vehicle.

Will the Bendix ABS-6 Advanced with ESP system work with other manufacturers' suspension, brakes, wheel ends, transmission, etc.?

Yes. Bendix works closely with the OEs (Original Equipment manufacturers) to validate our robust stability system options with the component/system combinations offered by the OEs. Talk to your OE or dealer for more information.

Will the Bendix ABS-6 Advanced with ESP system be effective with drum brakes or a combination of drum and air disc brakes?

Yes. The system is highly flexible and designed to work with all brake types and sizes. Optimal system performance is achieved when the brakes are sized so that all wheels can utilize the maximum braking force available. The ability to decelerate a vehicle is depends on the amount of brake torque available . . . the more torque available, the greater the stability margin you can expect for your vehicle.

Will Bendix ABS-6 Advanced with ESP function with a tire monitoring system and, if so, does it react differently if a tire is low?

The system is designed to work on vehicles equipped with tire monitoring, as well as a wide variety of other ancillary vehicle systems. In the event of low tire pressure, or even a tire blowout where vehicle loss of control is a real potential, there is no difference in the way the system functions. ESP will assist the driver in maintaining directional control of the vehicle to help mitigate the potential for rollover, jackknife or other stability-related issues.

If a fault occurs with the ESP® system, how will the driver and/or the technician know?

If a fault does occur, the ESP lamp (previously the ATC light) will illuminate on the dash. If the vehicle ABS system is also affected, both the ABS warning lamp and the ESP lamp will illuminate. In this situation the vehicle will have partial or no ESP function but is still drivable and should be scheduled for service as soon as possible. Microsoft Windows-based Bendix® ACOM™ diagnostics software (available on CD in the literature center www.bendix.com or download from www.bendix.com.) will allow the service technician to quickly and efficiently to troubleshoot and repair the problem. ACom diagnostics software provides testing of individual components before or after repair, ensuring that the problem has been correctly diagnosed and repaired.

If a fault occurs with the ABS system, will the ESP system still function?

If a fault occurs that is rooted in the ABS system, both the ABS warning lamp and the ESP lamp will illuminate to notify the driver. In this situation the vehicle will have no ESP function but is still drivable and should be scheduled for service as soon as possible. To minimize potential service downtime, Bendix® ACOM™ diagnostics – a Microsoft Internet Explorer-based system – allows a technician to quickly and efficiently to troubleshoot and repair the problem. The system also provides testing of individual components before or after repair, ensuring that the problem has been correctly diagnosed and repaired.

Safety

Will a stability system encourage my drivers to drive more aggressively?

It should not. The Bendix® ABS-6 Advanced with ESP® stability system was designed to supplement safe driving practices, not to enable or encourage drivers to drive differently than they do today. The system actively discourages aggressive driving by reducing vehicle speed after a system intervention to a level that is below the critical stability threshold.

I have safe drivers, why do I need this system?

Even the best drivers can find themselves in unsafe scenarios due the many variables they face on the road including inclement weather, less experienced drivers and changing road conditions, to name just a few. The Bendix® ESP® system is meant to supplement safe driving practices and to assist the driver when the unexpected happens. ESP can react more quickly than a human in most situations and, unlike drivers, it can selectively apply the vehicle brakes at individual wheel ends to avoid a potential yaw situation. Stability systems are about vehicle safety and the mitigation of serious incidents. Not all fleets or operators face the same degree of risk. Bendix has an analytical tool that can help you analyze your fleet's unique level of risk and the potential impact that risk might pose for your particular business. Talk to a Bendix account manager for more details on this convenient and user-friendly tool.

Reports show that the national averages for fatal crashes have recently gone down. With that in mind, why do I need a system?

National accident statistics have nothing to do with the stability, safety or performance of an individual vehicle. The safety of your drivers and your vehicles is an important consideration for all fleets, so why not buy the most well-equipped vehicles available. At Bendix our commitment is to constantly improve vehicle safety. The introduction of advanced vehicle stability systems demonstrates that focus and commitment.

Take the Next Step

I'm interested. What other factors should I consider when making my decision about Bendix® ABS-6 Advanced with ESP® ?

While there are many factors that can impact your decision, there are a few primary elements you should consider:

- ***Your level of commitment to the safety of your drivers and vehicles***
  Bendix is strongly committed to support you in improving the safety of commercial vehicles on the road and is actively working with many OEs to make ESP systems available.

- ***Your current level of financial exposure to stability-related incidents***
  Bendix has developed an analytical tool to assist you in developing a sound business case for an intelligent investment in stability for your fleet. Ask your Bendix account manager for a copy of the calculator for your fleet.

- ***Changes in driver turnover; route consistency; geographic and weather conditions encountered***
  - **Driver turnover**: Is your driver turnover high? Do you have new drivers that are often unfamiliar with the equipment that you use in your fleet?
  - **Route Consistency**: Do your routes change frequently?
  - **Geographic conditions**: Does your fleet travel hills and mountains?
  - **Weather conditions:** Does your fleet encounter rain, snow or ice often?

  If you answered yes to *any* of the above questions, the Bendix® ABS-6 Advanced with ESP® system may be an important consideration in your next vehicle purchase.

- ***Is the Bendix® ABS-6 Advanced with ESP® right for you?***
  Do your homework and ask as many questions as you wish. By carefully collecting and evaluating the data in addition to reviewing this document, you should be ready to make the decision that is right for you.

How do I find out more?

To learn more, contact your current OE/dealer or your Bendix account representative for additional information. To find the Bendix account representative for your area, visit www.bendix.com/contacts, or call 1-800-AIR-BRAKE (1-800-247-2725). You should also visit the Bendix web site (www.bendix.com) for additional updates to this document as well as other valuable information.

Is Bendix® ABS-6 Advanced with ESP® available on the vehicle model that I want to buy?

To find out if Bendix ABS-6 Advanced is available for your vehicle, contact your current OE/dealer or a Bendix account representative at www.bendix.com/contacts or 1-800-AIR-BRAKE (1-800-247-2725). You can also visit the Bendix web site (www.bendix.com) for vehicle availability.

What if the Bendix ABS-6 Advanced with ESP stability system is not available on my vehicle configuration?

Bendix ABS-6 Advanced with ESP is available from a number of vehicle manufacturers on a variety of models and specifications. If the vehicle you have selected is not currently included on the list, talk to your dealer about requesting that the OEM release the Bendix ABS-6 Advanced system for your specific application. Or, review the vehicle specifications currently available with Bendix Advanced with ESP to see if a slight modification to your current configuration will enable ESP availability for your fleet.

Please note: This document is designed to assist you in the stability system decision process, not to serve as a performance guarantee. No system will prevent 100% of the incidents you may experience. This information is subject to change without notice.