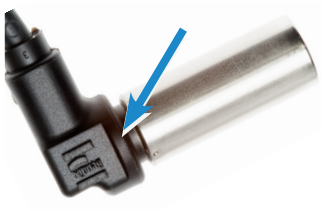
Bendix® WS-24™ Antilock Wheel Speed Sensor

VARIOUS BENDIX® WS-24™ WHEEL SPEED SENSORS

WS-24 Wheel Speed Sensors with Trade Dress

90° Angle WS-24 Sensor



Straight WS-24 Sensor

Straight WS-24 Sensor

90° Angle WS-24 Sensor

NOTE: *The appearance of the WS-24 WSS may vary depending upon the date and location of manufacture, but they are interchangeable provided they are the same type (e.g., straight or 90°).*

Connectors

						
Packard® GT 150 Series (Female)	Packard Metripack 150.2 Series (Female)	Deutsch® DTM06 Series (Female)	Packard Metripack 280 Series (Male)	Packard Metripack 280 Series (Female)	Deutsch DT04 Series (Male)	Standard Round 2-Pin DIN Connector (Socket)
Suggested Mating Connector						
Metripack 150.2 Black 2-way Unsealed Male Connector	Packard Metripack 150.2 Series (Male)	Deutsch® DTM06 Series (Male)	Packard Metripack 280 Series (Male)	Packard Metripack 280 Series (Male)	Deutsch DT04 Series (Female)	Standard Round 2-Pin DIN Connector (Socket)

Figure 1 – Wheel Speed Sensors and Connectors

DESCRIPTION

The Bendix® WS-24™ Wheel Speed Sensor (WSS) is an electromagnetic device used to obtain vehicle speed information for an antilock controller. When the wheel rotates, the sensor and an exciter ring (sometimes called a “rotor” or “tone” ring) generate a simple AC signal. This signal is sent to either the brake controller (Bendix® EC-60™ or Bendix® EC-80™) or the Global Scalable Brake Control electro-pneumatic modulator (Bendix® GSBC® EPM-90™), which analyzes the data and commands the Antilock Braking System (ABS) accordingly.

Specifically, the WSS consists of a coil, pole piece, and a magnet. The exciter ring is a steel ring or gear-like device that has regularly spaced high and low spots called “teeth.” The WSS is mounted in a fixed position, while the exciter ring is installed on a rotating member (typically part of the hub) so that its “teeth” move, in close proximity, past the tip of the sensor.

The WS-24 WSS is available in both straight and 90° versions to accommodate axle/wheel space limitations. *See Figure 1*.

GENERAL SAFETY GUIDELINES

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following guidelines should be observed AT ALL TIMES:

- **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels. Always wear personal protection equipment.**
- **Stop the engine and remove the ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.**
- **Do not attempt to install, remove, disassemble, or assemble a component until you have read, and thoroughly understand, the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
- **If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle. If the vehicle is equipped with a Bendix® AD-IS® air dryer system, a Bendix® DRM™ dryer reservoir module, a Bendix® AD-9si®, AD-HF®, or AD-HFi® air dryer, be sure to drain the purge reservoir.**
- **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.**
- **Never exceed manufacturer's recommended pressures.**
- **Never connect or disconnect a hose or line containing pressure; it may whip and/or cause hazardous airborne dust and dirt particles. Wear eye protection. Slowly open connections with care, and verify that no pressure is present. Never remove a component or plug unless you are certain all system pressure has been depleted.**
- **Use only genuine Bendix® brand replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, wiring, etc. must be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.**
- **Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.**
- **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**
- **For vehicles with Automatic Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.**
- **The power MUST be temporarily disconnected from the radar sensor whenever any tests USING A DYNAMOMETER are conducted on a vehicle equipped with a Bendix® Wingman® system.**
- **You should consult the vehicle manufacturer's operating and service manuals, and any related literature, in conjunction with the Guidelines above.**

TECHNICAL INFORMATION

Electrical Connector	2 pin
Sensor Resistance at Extreme Temperatures	1100 ohms at -40°F (-40°C) | 3400 ohms at 428°F (220°C)
Sensor Resistance at Ambient Temperatures	1575 to 2100 ohms at 68°F (20°C)
Output Voltage	Minimum of 0.250 VAC (wheel speed of at least 0.5 revolutions per second and a sensor gap of less than 0.015 in. [0.38 mm])
Sensor Gap	Nominal: 0.004-0.015 in. (0.1-0.38 mm)* Maximum: 0.06 in. (1.5 mm)**
Sensor Body Outer Diameter	0.627 in. (1.6 cm)

***NOTE:** Normal wheel runout will automatically push the sensor head out and provide some minimum clearance between the sensor and the exciter ring, typically >0.1mm.

****NOTE:** A sensor gap near the maximum value may result in Diagnostic Trouble Codes (DTCs) or faults being triggered. If the wheel rotation pushes the sensor to a gap near or in excess of 1.5 mm, inspect the wheel end for excessive bearing runout and damage to the exciter ring or exciter ring mounting as specified in this document

OPERATION

The WSS magnet and pole piece form a magnetic field. As the teeth of the exciter ring pass by the sensor, the magnetic field is altered, which generates AC voltage in the sensor coil. Each time an exciter tooth and its adjacent space move past the tip of the sensor, an AC voltage "cycle" is generated.

The number of AC cycles per revolution of the vehicle's wheel depends on the number of teeth in the exciter ring and the radius of the wheel and tire*, which is programmed into the brake controller. Using the programmed data, the controller can calculate vehicle speed by analyzing the frequency of AC cycles sent by the WSS. The frequency of AC cycles is directly proportional to the rotational speed of the wheel. *See Figure 2*.

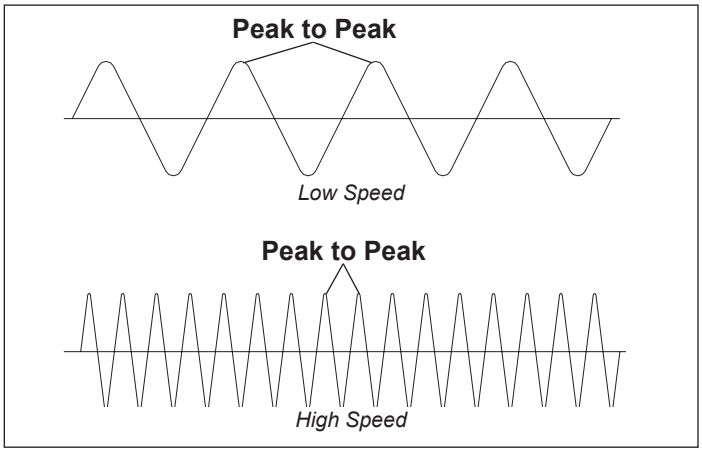


Figure 2 – WSS Voltage Cycle Output

AC voltage is also proportional to speed, but voltage is not used to determine speed. It is only an indication of AC signal strength. The amount of AC voltage generated by a specific WSS depends on the distance, or "gap," between the tip of the sensor and the surface of the exciter ring. Voltage increases as the sensor gap decreases.

Typically, the WS-24 WSS is installed in mounting blocks that are welded to the axle housing, or integrated into the design of the axle housing or torque plate. *See Figure 3*. The WS-24 WSS is protected by a stainless steel sheath, which is the visible, silver cylinder portion of the sensor. The sensors are designed to be used with stainless steel clamping sleeves (sometimes referred to as a "retainer bushing," "friction sleeve," or "clip"). *See Figure 4*. The clamping sleeve provides a friction fit between the bore of the mounting location and the WS-24 WSS which allows the sensor to "slide" back and forth under force, but remain in position when the force is removed.

**The radius of the wheel and tire, referred to as the Static Loaded Radius (SLR), is typically provided by the tire manufacturer.*

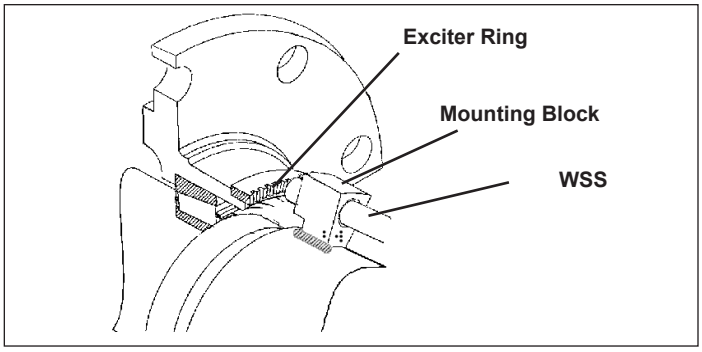


Figure 3 – Wheel End ABS Components

When the WS-24 WSS is inserted all the way into the mounting block and the wheel is installed on the axle, the hub exciter ring contacts the sensor. When the wheel begins to spin, the exciter ring will push the sensor backwards, achieving the correct running clearance for proper operation. Normal bearing play will also "bump" the sensor away from the exciter ring, which also contributes to maintaining the correct running clearance, or air gap, between the sensor and exciter ring.

Note that older Bendix® clamping sleeves with part number 800697 are obsolete and cannot be used with the WS-24 WSS. **Only use the correct replacement stainless steel clamping sleeves with part number K134931** to avoid problems associated with reduced retention force, such as unwanted sensor movement or loss of ABS or stability control systems.

Figure 4 – Clamping Sleeves

⚠ WARNING

Excessively rough tone ring surfaces or failure to use the appropriate clamping sleeve could result in damage to the WSS. WSS damage could lead to reduced system functionality and/or an increased risk of collisions, injury, and/or death.

MAINTENANCE

The WSS itself cannot be repaired. If the sensor is visibly damaged, replace the sensor. If the sensor is not visibly damaged, but is causing the brake controller to set a Diagnostic Trouble Code (DTC) or fault, refer to the *Troubleshooting* section of this document for the correct troubleshooting procedure. Maintenance operations for the WSS are limited to cleaning, visual inspection, and functional checks only.

CLEANING

Clean the area around the WSS and the WSS electrical connector to remove debris and contamination. The preferred method for cleaning these areas of dirt, grit, salt, or other build-up is water with a gentle brush. It is permissible to use a gentle detergent, but strong acid or chemical cleaners should be avoided.

NOTE: When cleaning the WSS, look for and remove any metallic debris stuck by magnetism to the head of the sensor.

It is also permissible to use a pressure washer, but the technician should be careful not to hold the pressure washer close to the WSS, use excessive pressure, or spray water directly at the electrical connectors or the sensor itself.

⚠ WARNING

Be cautious while using a pressure washer to clean components. Appropriate Personal Protective Equipment (PPE) is recommended (e.g., eye protection) while using a pressure washer. Failure to use PPE could result in personal injury. Rubber parts, sealing interfaces, and electrical components or covers should not be directly sprayed with the high-pressure jet. Failure to use caution when performing maintenance could lead to serious vehicle braking, instability, and performance issues, and/or collisions, injury, and/or death.

MAINTENANCE SCHEDULE

1. Every 3 months; 25,000 miles; 900 operating hours; or during the vehicle chassis lubrication interval, perform the *Visual Inspections* in this document.
2. Every 12 months; 100,000 miles; or 3600 operating hours, perform the *Diagnostics Function Test* in this document.

VISUAL INSPECTION

Prior to conducting a visual inspection, clean the sensor and associated wiring and electrical connectors per the *Cleaning* section of this document.

Visually inspect the WSS, sensor mounting, sensor cable, and electrical connector:

- Inspect the sensor head, looking for signs of mechanical damage, metal shavings, or other signs of mechanical failure.
- Inspect the sensor cable for cuts, evidence of pinching or wear, excessive corrosion, or abrasions with exposed wiring. Make sure the sensor mounting is securely attached to the axle housing.
- Inspect the electrical connector and terminals for signs of damage, corrosion, loose connections, or visible wires.
- Make sure the sensor, mounting bracket, and foundation brake components are not damaged.
- Inspect the WSS and sensor cable for signs of excessive heat, including melted or deformed sensors, plastic overmold, or wires.

If any of the previous conditions are noted on the WSS, replace the sensor and clamping sleeve according to the *Sensor Removal and Sensor Installation* sections of this document.

Perform a similar inspection of the vehicle harness connected to the WSS, ensuring all connectors are properly and securely installed. If damage is found on the vehicle harness, contact the vehicle OEM for instructions on how to troubleshoot, repair, or replace a damaged vehicle harness.

Visually inspect the exciter ring for damage and ensure the exciter ring is securely mounted to the wheel hub. If damage to the hub or exciter ring is discovered, or excessive run-out is suspected, repair or replace the hub according to the hub manufacturer's instructions.

⚠ WARNING

Melted or deformed WSS or sensor cables are signs of overheating at that wheel end, and signs that the sensor has exceeded the operational temperature limit of 320°F (160°C). Immediately replace the WSS and identify and correct the source of excessive temperatures at that wheel end before returning the vehicle to service. Failure to identify and correct the root cause may cause reduced braking performance, early friction replacement, damage to foundation braking components, reduced system functionality, and/or an increased risk of collisions, injury, and/or death.

TROUBLESHOOTING

The most common indication of a damaged or malfunctioning WSS is a DTC logged by the brake controller when a fault is detected.

Depending on the severity of the DTC or fault and which features are impacted, one or more warning lamps may be displayed to the driver on the dashboard.

To appropriately diagnose, troubleshoot, and repair DTCs or faults, connect to the vehicle using Bendix® ACom® Diagnostic Software or an appropriate OEM diagnostic tool.

TEST PREPARATION

Prior to conducting any troubleshooting testing, perform the following steps:

1. Ensure that the vehicle is in a location where it can be safely worked on.
2. Chock the wheels on the vehicle to prevent unintended movement.
3. Clean and visually inspect the WSS, sensor wire, electrical connector, and associated vehicle harnessing per the *Visual Inspection* section of this document.
4. If damage is found during the inspection, replace the damaged components as necessary before proceeding.
5. Using ACom Diagnostic Software or an appropriate OEM diagnostic tool, generate and save a DTC report. Once the report has been generated and saved, attempt to clear/reset active DTCs. If DTCs cannot be cleared, continue with the *Test Preparation.*
6. Safely lift the wheel that the sensor is monitoring so it can be turned easily by hand.

⚠ WARNING

If the sensor is on an axle with parking brakes, it may be necessary to release the parking brakes to spin the wheel. Always be sure that the vehicle is chocked and will not move when the parking brakes are released. Refer to the vehicle OEM for instructions on the proper method to safely lift and immobilize a vehicle. Failure to chock the wheels could lead to vehicle damage, property damage, injury, and/or death.

STATIONARY TROUBLESHOOTING

There are two general ways to verify the operation of a specific WSS while the vehicle is stationary, depending on the DTC or fault being investigated:

1. Diagnostic Functional Test
   (using a computer-based diagnostic tool)
2. Electrical Functional Test
   (using a multimeter)

All troubleshooting tests require that the *Test Preparation* steps be fully completed prior to beginning.

Diagnostic Functional Test

To diagnose DTCs or faults with a WSS using a computer diagnostic tool, perform the following steps:

1. Make the vehicle safe for service by following the steps in the *Test Preparation* section of this document.
2. Connect the vehicle with an appropriate diagnostics tool and choose the WSS monitoring function.
   a. If ACom Diagnostic Software is available, sensors can be read live.
   b. For other diagnostic tools, contact the diagnostic tool manufacturer for information on that tool's capabilities.
3. Spin the wheel at a speed of at least 0.5 revolutions per second.
4. The monitor on the diagnostic tool should show wheel speed, and the speed should be proportional to the rate at which the wheel is turned.
5. If no speed is shown, or if the speed is inconsistent, ensure that the sensor is properly installed per the *Sensor Installation* section of this document.
6. If the problem persists, electrically troubleshoot the sensor per the *Electrical Troubleshooting* section of this document.
7. If the sensor is properly installed and fails the *Electrical Troubleshooting Tests*, replace the sensor.

Electrical Functional Test

Prior to testing, ensure that the vehicle is not at an extreme temperature. If the vehicle is not at a temperature close to ambient, the measured nominal resistance or AC voltage values may fall outside the ranges given below. Extremely high or low wheel end temperatures can contribute to misleading readings while testing this component. At ambient temperature (68°F [20°C]), the sensor resistance can vary between **1575 and 2100 ohms.**

NOTE: Do not test the WSS in extreme temperatures. The sensor resistance can vary from 1100 to 3400 ohms between the low operational limit (-40°F or -40°C) and the high operational limit (428°F or 220°C).

To avoid excessive wear to the electrical connector seal on the WSS, it is recommended to first check sensor resistance and AC voltage output at the Electronic Control Unit (ECU) (for EC-60 and EC-80 applications), the trailer ABS module (Bendix® TABS™), or Bendix® GSBC® EPM-90™ (for GSBC applications) electrical connection for that particular WSS. If the resistance or voltage output is not within the stated parameters at this location, perform the test at the next connector, typically the wheel end. This process helps to identify harness problems as opposed to WSS problems.

For more information on pinouts and wiring diagrams, *refer to the applicable technical document on B2Bendix.com.*

1. Make the vehicle safe for service by following the steps in the *Test Preparation* section of this document.
2. Ensure that the WSS is properly installed per the *Sensor Installation* section of this document.
3. Starting at the brake controller or EPM (as appropriate, depending on system type):
   a. Inspect the connectors and terminals for corrosion, physical damage (bent), or loose connections. If possible, repair and/or clean the connector and terminals.
   b. Disconnect the electrical connector.
   c. On the sensor side of the disconnected electrical connector, use a volt-ohm meter to measure the following values:
      - Setting the multimeter to resistance measurement, measure the resistance across the correct pins for the WSS. At ambient temperature (68°F [20°C]), the resistance should be between 1575 and 2100 ohms. Record your measurement.
      - Setting the multimeter to AC Volt Mode, spin the elevated wheel at a speed of at least 0.5 revolutions per second. The output voltage should read 0.25V or higher. Record your measurement.

   d. If the resistance, voltage, or both measurements are outside the given parameters, perform the following:
      - Examine the wheel end for other causes of inconsistent WSS performance, including:
        - Excessive bearing play or runout.
        - Metallic debris stuck by magnetism to the head of the sensor.
        - Signs of excessive heat at the wheel end, including melted or deformed sensor or sensor cables.
        - A warped, damaged, loose, or incorrectly installed exciter ring.
      - Reposition the sensor by gently pushing it closer toward the wheel until it touches the exciter ring. Repeat the voltage measurement as outlined in step 3c.
      - If the measurements are still outside the given parameters, reconnect the electrical connector that was disconnected in step 3 (b). Proceed to the next electrical connector closer to the WSS.
        - If you reach another electrical connector before reaching the WSS, restart at step 3 (a) and continue through the harness.
        - If the measurements were taken at the electrical connector on the WSS cable itself, and the sensor is properly installed, replace the sensor and clamping sleeve per the *Sensor Removal/Installation* sections of this document.

   e. If the resistance and voltage values now measure within parameters, the problem is in the section of harness between the currently disconnected electrical connector, and the one tested immediately before. Repair the harness according to the vehicle OEM's guidelines for harness repairs.
   f. If the resistance and voltage readings are both within the acceptable limits, the sensor and sensor wiring harness are not the causes of the DTC or fault.
      - Reconnect the sensor.
      - Examine the wiring harness and ECU connector for causes of failure, such as pinched wires, loose pins, abrasions, exposed wires, etc.
   g. Repair any problems or defects found in adjacent systems. After repairs are complete, either repeat the steps in *Stationary Troubleshooting* or perform a *Road Test* to confirm that the repair is complete.

ROAD TEST

To validate that a WSS DTC or fault has been repaired, the vehicle can be taken on a road test:

1. Test drive the vehicle in a safe area.
2. Reach a minimum speed of 15 mph (24 kph).
3. Make multiple right- and left-hand turns while driving.
4. Vary the vehicle speed, including coming to a complete stop using the brakes multiple times.

Technicians should observe the following during a test drive:

1. Depending on where the WSS is installed, the ABS lamp on the vehicle dashboard (or the trailer ABS lamp) should not illuminate during the test drive or after the test drive is complete unless there are other DTCs or faults on the truck or trailer.
2. If ACom Diagnostic Software is available, wheel sensor output can be monitored and recorded live in the ACom diagnostic wheel speed window during the drive. All sensors should record speeds.

NOTE: Always obey all traffic laws when operating a vehicle. Do not attempt to operate ACom Diagnostic Software while the vehicle is in motion.
For additional troubleshooting information, *refer to the applicable ABS Service Data Sheet and BW2453, Bendix® Wheel Speed Sensor Checklist,* on B2Bendix.com.

SENSOR REMOVAL

WSS are typically not retained to the wheel end by anything other than friction. Simple hand tools – including a small pry bar, diagonal cutters, and a flashlight – may make removal of the WSS from the vehicle easier.

1. Make the vehicle safe for maintenance by performing the following steps:
   a. Ensure that the vehicle is in a location where it can be safely worked on.
   b. Chock the wheels on the vehicle to prevent unintended movement.

⚠ WARNING

Failure to chock the wheels could lead to vehicle damage, property damage, injury, and/or death.

2. Identify the location of the suspect WSS using either information from the brake controller, a DTC report, or feedback from the driver.
3. Remove as much contamination, dirt, and debris as possible from the WSS itself, as well as the electrical connector connecting the sensor to the vehicle harness. Refer to the *Cleaning* section of this document.
4. Identify and take note of any cable ties retaining the sensor to the vehicle. During re-installation, it will be necessary to replace the cable ties in the same location(s).
5. If cable ties are not a reusable type, cut and remove any cable ties holding the sensor cable to the vehicle.
6. Unplug the cable assembly from the vehicle harness, being careful not to damage the seal on the electrical connector.
7. Gently pry the sensor and clamping sleeve from the mounting block. Discard the old sensor and clamping sleeve.

SENSOR INSTALLATION

Sensor installation is the reverse of removal.

1. Inspect the WSS mounting location, and gently remove dirt or debris from the area if necessary.

⚠ CAUTION

Be careful not to damage the exciter ring while cleaning the sensor mounting location, as this usually means that the hub must be disassembled, replaced, and reassembled.

2. Install a new clamping sleeve fully into the mounting location, with the retaining tabs oriented toward the inside of the vehicle.

NOTE: Stainless steel clamping sleeves require that a high-temperature-rated silicon- or lithium-based grease be applied to the sensor body. This lubrication will keep the movement between the sensor and the clamping sleeve independent from one another.

3. Gently push the sensor into the mounting block hole until it bottoms out on the face of the exciter ring.

NOTE: DO NOT STRIKE the WSS during installation. This can damage the sensor, the sensor cable, and/or the exciter ring on the hub.

4. Secure the cable assembly to the knuckle/axle housing 3-6 in. (8-15 cm) from the sensor.
5. Apply a moderate amount of dielectric non-conductive grease to both the sensor connector and the harness connector.
6. Engage the connectors and push together until the lock tab snaps into place.
7. Inspect the wheel end for other signs of required maintenance (e.g., friction life remaining, oil leaks, excessive corrosion, air leaks, and/or mechanical damage). Correct any problems before returning the vehicle to service.

NOTE: It is important for the wheel bearings to be adjusted per the manufacturer's recommendations. Excessive wheel end play can result in excessive air gap where the sensor is pushed too far away from the exciter ring, leading to loss of ABS or stability control system operation.

8. Secure the sensor wires to the axle using cable ties using the same locations as were present on the vehicle from the original manufacturer, which were noted in *Step 4 of the Sensor Removal* procedure.
9. Clear any DTCs or faults that were set while the sensor was being replaced. Perform a road test per the *Functional Testing –Road Test* section of this document before returning the vehicle to service.

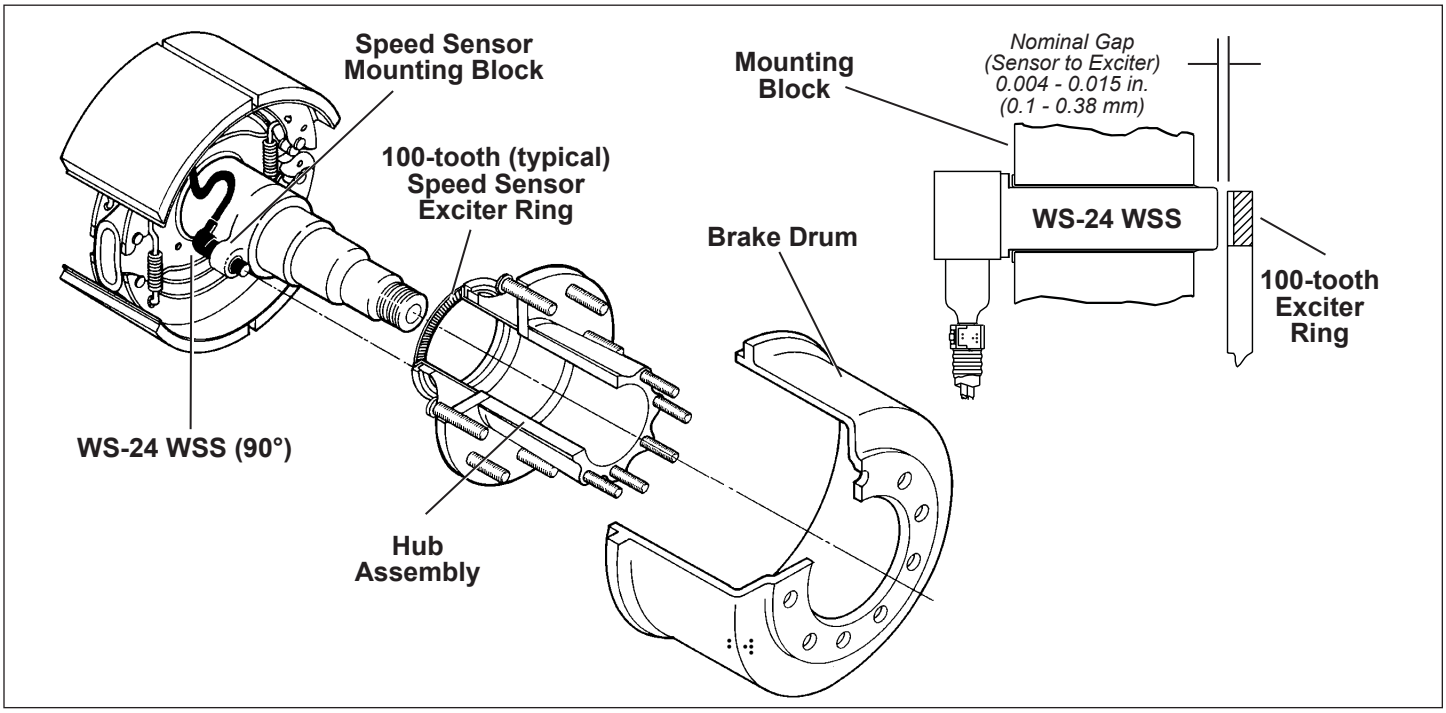


Figure 5 – WS-24 Wheel Speed Sensor Installation

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