

CVJ and Knuckle Design Optimization to Protect Inboard Wheel Bearing Seals from Splash

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ABSTRACT

For higher mileage vehicles, noise from contaminant ingress is one of the largest durability issues for wheel bearings. The mileage that wheel bearing sealing issues increase can vary due to multiple factors, such as the level of corrosion for the vehicle and the mating components around the wheel bearing. In general, sealing issues increase after 20,000 to 30,000 km. Protecting the seals from splash is a key step in extending bearing life. Benchmarking has shown a variety of different brake corner designs to protect the bearing from splash. This report examines the effect of factors from different designs, such as the radial gap between constant velocity joint (CVJ) slinger and the knuckle, knuckle labyrinth height and varying slinger designs to minimize the amount of splash to the bearing inboard seal. This report reviews some of the bearing seal failure modes caused by splash. This study also discusses the test methodology to confirm the robustness of the various designs and provides information on the effectiveness of different features to protect the corner from splash.

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INTRODUCTION

Why Protect the Bearing from Splash

Wheel bearings allow the wheels of a vehicle to rotate relative to the chassis. In addition to supporting the loads of the vehicle, a key requirement of wheel bearings is to avoid noticeable noise or vibration to the passengers. For higher mileage parts, one of the largest failure modes that can cause noise is water and contamination ingress through the seals. Warranty part reviews of high mileage parts show that a high percentage of the parts had contamination ingress through the inboard seals.

Original equipment manufacturers (OEMs) use a variety of different corner designs with different levels of splash protection. Hyundai referenced a warranty reduction of over 50% for a knuckle design that protected the bearing from splash relative to an open design [1].

OEM solutions for splash vary from wide lateral covers to designs with two separate stainless steel pieces. Several examples are shown in this paper. The effect of several design choices to protect the wheel bearing from splash was confirmed by running a Design for Six Sigma (DFSS) project.

Splash Related Failure Modes

Open corners allow more mud, water and debris to splash the inboard seal and wheel speed sensor (WSS).

Figure 1 shows an example of an inboard seal with lip wear. The highest wear is found on the axial lips shown at top of the figure.

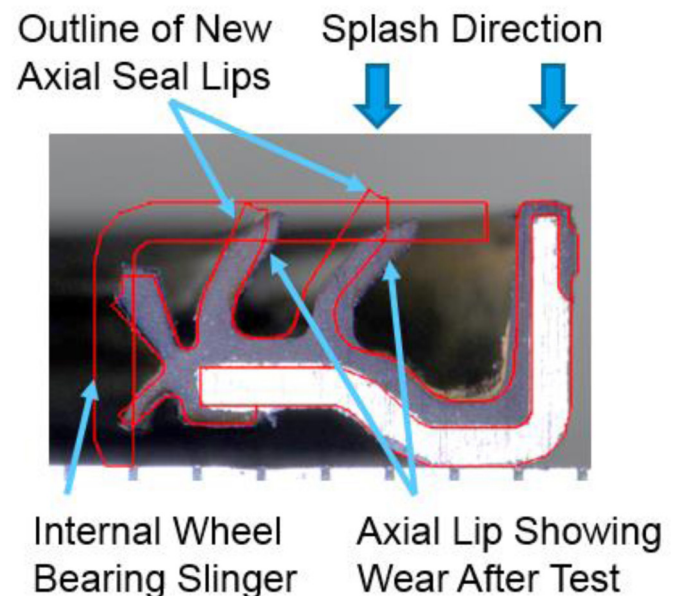


Figure 1. Shows lip wear of a seal that completed a seal contaminated durability test compared to the profile of a new seal and bearing slinger. The red outline shows the shape of the original seal lips and an internal bearing slinger.

Other failure modes include water entering the bearing through the static interfaces of the bearing seal. Figure 2 shows the paths of contaminant entry into a wheel bearing seal. Path 1 is the interface between the

bearing outer ring inner diameter (ID) and the seal outer diameter (OD). This is a static, non-rotating, interface. Vehicle durability and warranty parts have shown contaminant ingress through this path on some vehicle applications. Path 2 shows the path between the bearing slinger and the seal lips. This is a dynamic path where rubber seal lips rotate relative to an internal slinger that is part of the bearing assembly. Warranty part reviews have shown that this path is one of the higher warranty failure modes. Path 3 shows the path between the bearing slinger ID and the bearing inner ring OD. This failure mode is typically not found in wheel bearing warranty, unless there was a problem with the bearing slinger design or manufacturing issues with the bearing slinger.

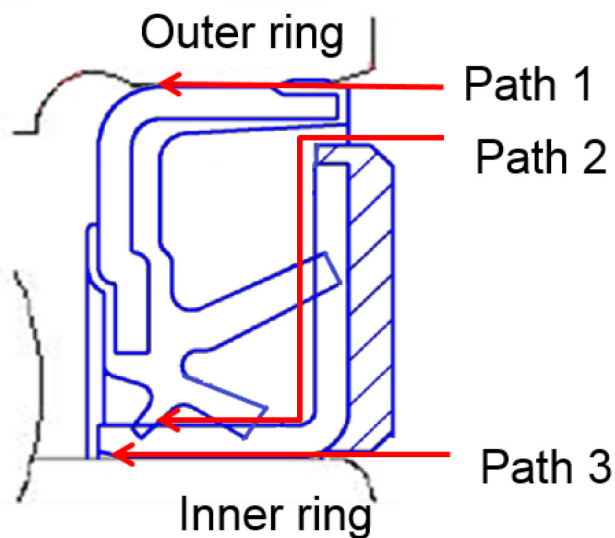


Figure 2. Example inboard bearing seal showing three paths of water entry into the bearing.

Many current automotive designs use a magnetic encoder with a discrete WSS as shown in [figure 3](#) below. The encoder is typically bonded onto the wheel bearing slinger with an adhesive. Debris can damage the magnetic encoder on the bearing seal or damage the wheel speed sensor, causing ABS (anti-lock braking system) faults in the vehicle. An example of wheel speed sensor wear is shown in [figure 4](#).

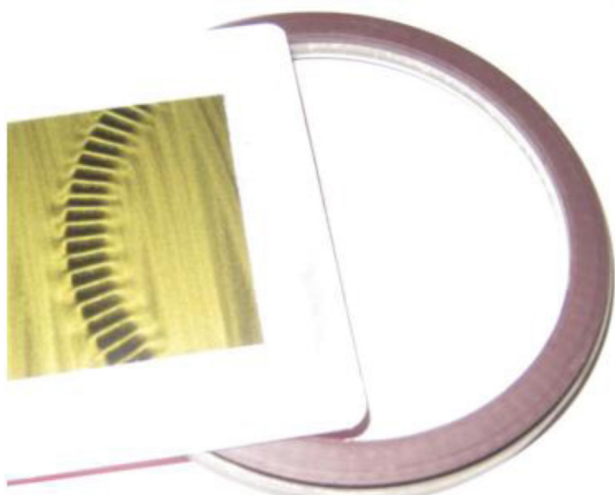


Figure 3. An inboard bearing seal assembly with a magnetic encoder. The magnetic particle film at the left of the figure highlights the magnetic poles on the encoder, which generate the ABS signal.

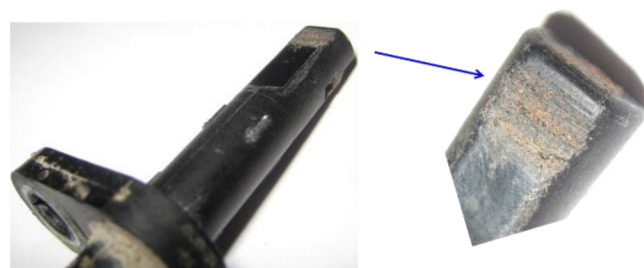


Figure 4. Shows two views of wear on the wheel speed sensor.

[Figure 5](#) shows the magnetic encoder and wheel speed sensor in an example vehicle corner.

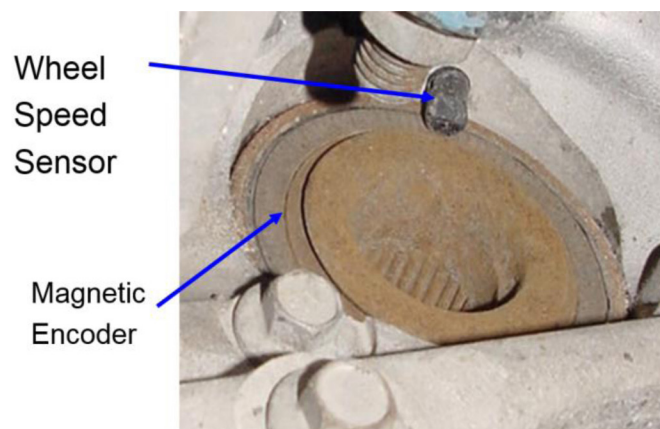


Figure 5. An inboard view of an open corner. This design has a magnetic encoder, which is part of the bearing inboard seal. The discrete WSS shown at the top of the fixture bolts to the knuckle. The WSS is separate from the wheel bearing.

Examples of Different Types of Splash Protection

A brake corner typically includes the wheel bearing, knuckle, rotor, dust shield and caliper. This paper concentrates on the protection provided by the knuckle and constant velocity joint (CVJ). A CVJ slinger is a stamped metal or plastic part that is pressed onto the CVJ bell. The name slinger refers to a rotating component that tries to sling water and mud away from the component when it is rotating on the vehicle. Slinger can apply to either the CVJ slinger or the bearing seal slinger. For the remainder of this paper, the term slinger will apply to the CVJ slinger.

Various types of brake corner assemblies are reviewed below.

[Figure 6](#) and [figure 7](#) show examples of open corners. [Figure 8](#) shows a corner with a wide knuckle. For this type of design, the tone ring or CVJ outer ring are designed to have a small radial gap with the knuckle. The CVJ shaft for this design may have a metal tone ring. [Figure 9](#) shows a knuckle that has 360-degree knuckle protection around the bearing, but the knuckle is narrower.

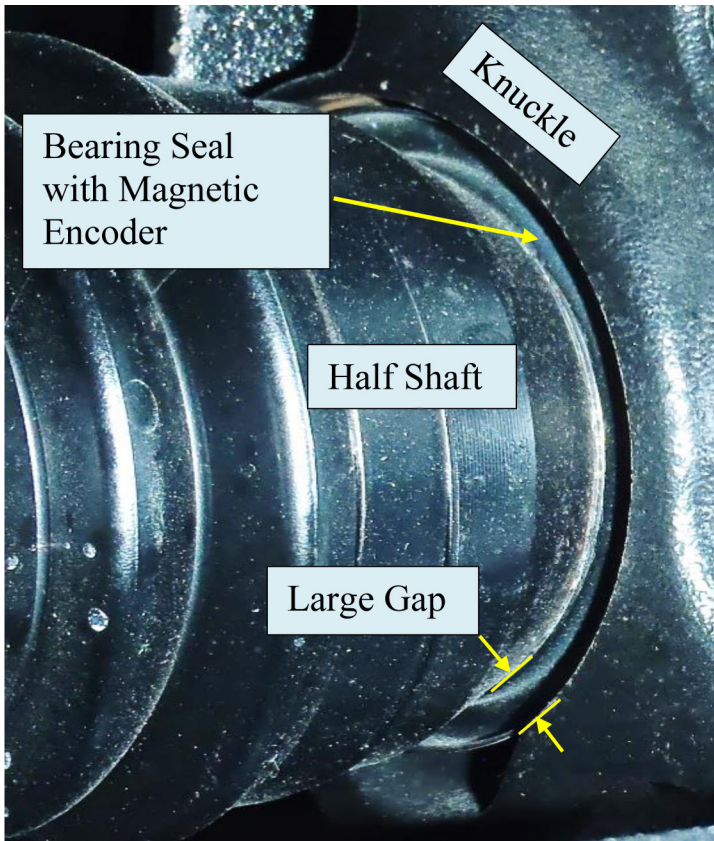


Figure 6. Example of an open corner with large radial gap between the half shaft and knuckle.

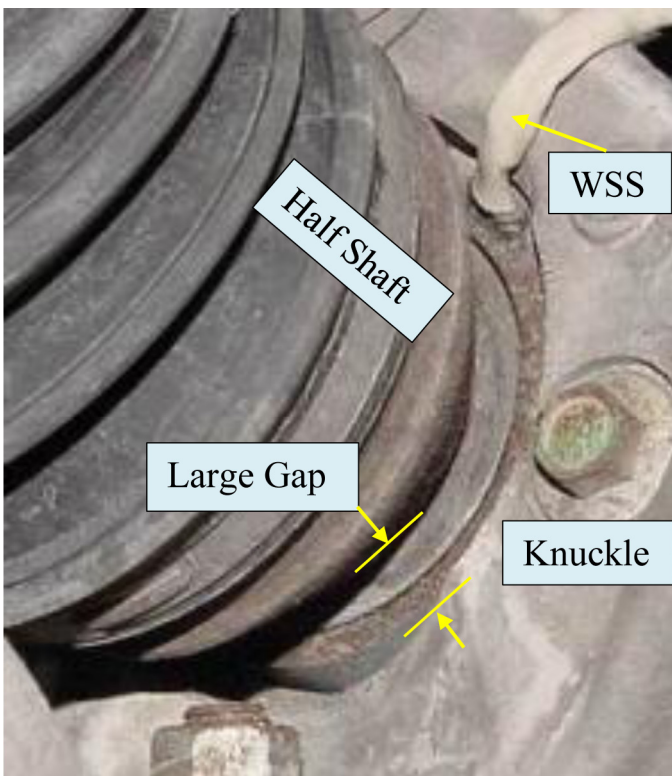


Figure 7. Example of an open corner with a large gap between the halfshaft and the knuckle. This wheel bearing uses an integrated WSS design, where the WSS is part of the bearing assembly.

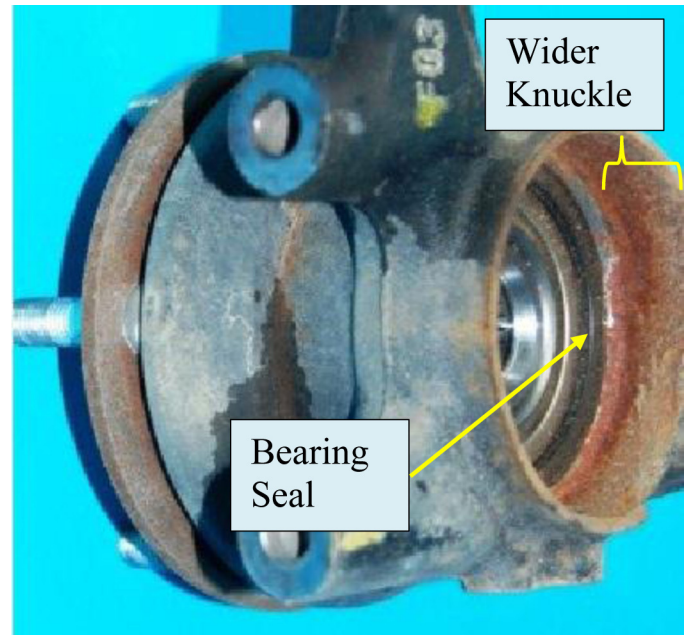


Figure 8. A corner design with a wide knuckle to protect the bearing seal.



Figure 9. Wheel bearing and knuckle. The width of knuckle protection is narrower than [figure 8](#).

[Figure 10](#) shows a design that uses two stainless steel inserts. A stainless steel slinger is pressed onto the CVJ bell. A second stainless steel insert is pressed into the knuckle bore. This insert has a small step that aids in assembly and creates a small labyrinth. This design has a small gap between the stampings.