

Sacrificial Shield for the Wheel Hub Bearing Flange to Maintain Low Brake Rotor Lateral Runout

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ABSTRACT

Corrosion is one of the main issues causing noise, vibration and harshness (NVH) in the wheel-end brake system. This paper describes the development of a sacrificial shield, mounted between the hub bearing unit (HBU) flange and the brake rotor, in order to avoid the forming of corrosion. The zinc (Zn) coated layers on the sheet metal shield provide a chemical defensive mechanism as it takes steel's place in the corrosion reaction.

Consequently RED rust will not start forming until all the Zn has been converted to WHITE rust. The duration of the conversion period is the "temporary corrosion protection period" for the HBU and rotor flanges and can maintain the delivered brake rotor Lateral Run Out (LRO) up to the first scheduled service for the rotor.

If each time the Sacrificial Shield is replaced when brake rotor service takes place, the proper functioning and service life of the brake system will be prolonged.

1. INTRODUCTION

Wheel-end service problems often result when corrosion between the interfaces of the hub bearing flange and brake rotor causes bonding between the different parts. Not only makes this disassembly costly, but also creates unevenly rough and non flat mating surfaces.

The assembly of a new brake rotor on a corroded HBU flange can therefore result in excessive brake rotor LRO.

The effects while braking are brake pedal pulsations, vibrations, onset of loud noises, localized overheating of the brake rotor and finally driver dissatisfaction.

1.1 Garage maintenance to compensate for LRO

- Clean HBU flange and brake rotor flange with a steel brush or sand paper
- Measure peak runout on hub and rotor flanges and match for minimal LRO, and/or
- Machine - turn the brake rotor when mounted on the HBU, and/or
- Dismount rotor and machine on a lathe
- Note: A used rotor can be machined, however a new rotor should not be turned, or
- Apply a tapered shim between hub and brake rotor flanges. Accepted by most car manufacturers

1.2 Bearing treatments to compensate for LRO

To meet the overall OEM LRO specification HBU flange faces are often machined to a very tight LRO tolerance capable of 0,010 mm.

This accurate LRO can only be maintained at service conditions if the forming of corrosion of the HBU flange can be delayed.

Flange treatments or processes to delay the forming of corrosion can aim for a SHORT TERM or a MEDIUM TERM protection period.

- SHORT TERM - approximately 3-years (Fig. 01)
Dosing of Molykote anti-seize paste beads on the HBU flange and the brake rotor pilot section. This method only protects up to the first brake rotor service interval. A cleaning operation is needed to create a HBU flange surface quality good enough to mount a new brake rotor with LRO according to specification.



Fig. 01/ Molykote paste beads on the flange

- MEDIUM TERM – approximately 3-5 years (Fig. 02)
A coating on the HBU flange gives corrosion protection for a longer period. However these coating treatments are not in-line processes for cost and space reasons and sub-contracted therefore. The flange LRO is then already fixed and mostly beyond the OEM LRO specification..



Fig. 02 / Sub-contracted coated flange with a fixed LRO

A longer LRO maintenance period than 5-years will reduce the complaints about the brake system in the vehicle manufacturer and reduce maintenance cost for the car owner.

2. MAIN SECTION

2.1 Objectives

- To develop a low cost coating process to protect the hub bearing unit flange and brake rotor hat section interface as well as brake rotor pilot section against corrosion for the period of OEM delivery up to the first brake rotor service interval for the car.
- The coated HBU flange should meet the accepted OEM in-line wheel-end LRO assembly specification of maximum 0,050 mm measured on the brake rotor. The contribution of the coating thickness variation to the LRO of the HBU flange should therefore be as small as possible (max. 0,005 mm).
- The coating application should support a LONG TERM service life of the brake system (5-years and longer), i.e. brake rotor LRO, reduction of NVH and maintenance cost.

2.2 Main coating selection criteria

On the basis of the required coating application performance, implementation for in-line manufacturing and assembly, the following main criteria were laid down for the selection and development of the coating process:

- Coating and process cost applied should be at an acceptable automotive cost level
- Process should fit current in-line manufacturing and assembly procedures, cost and space wise
- 3-5 years corrosion protection on the basis of corrosion resistance tests according to SAE J2334
- HBU flange LRO max. 0,010 mm + minimal coating thickness variation (max. 0,005 mm) in order to meet OEM accepted brake rotor LRO value of maximum 0.050 mm
- Resistance to brake fluid, preservatives, cleaning fluids
- No torque retention. Apply a metallic coating in order to resist to bolt load and fretting and fail safe reasons
- Sufficient heat transfer at braking conditions. According the Grossglockner test, the maximum temperature on the outer diameter of the flange is approximately 150-160°C. This test is a downhill "drive" from the famous mountain "Grossglockner" in Austria. The coating melt temperature of the metallic coating should well be above the 160°C.
- No negative effect for the HBU performance

2.3 Coating process selection

The team performed the basic coating selection process based upon supplier technical specifications, quotations and initial testing activities.

It turned out that none of the current available coatings and processes on the market could meet all the main criteria for direct coating on the HBU flange.

The project team decided therefore to investigate a coating on a separate exchangeable component for the interface between the HBU flange and the brake rotor. This resulted in the Sacrificial Shield concept where the shield is made of thin sheet steel material with a zinc coating on both sides.

2.4 The Sacrificial Shield concept

The idea of using a sacrificial shield is based on the principle of galvanic cathodic protection of a sacrificial anode (Fig.03).

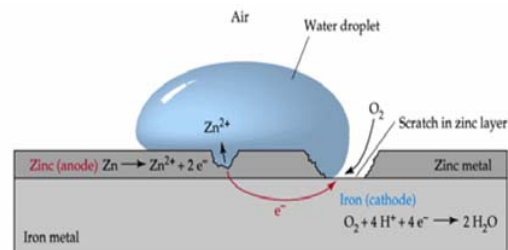


Fig. 03 / Sacrificial working principle. Zn converts into "White" rust before changing into "Red" rust

- Cathodic protection protects a metal from corrosion connecting the metal to another metal
- (a sacrificial anode) that is more easily oxidized
- The Zn layer provides a chemical defensive mechanism as it takes steel's place in the corrosion reaction.
- In practice it means that Zn corrodes preferentially to the steel. Therefore RED rust (Fe_2O_3) will not start forming until all the Zn has been converted to WHITE rust (ZnO)

A zinc coating is the most common method for protecting surfaces against corrosion. It is like a mechanical barrier similar to paint.

Hot-dipped Zn galvanized steel sheet material is commercially available with a Zn layer thickness of 0.025 mm. The corrosion protection period can be prolonged if the Zn coating layer thickness is increased e.g. to 0.030 mm or 0.035 mm.

For stiffness reasons a steel sheet material with a minimal thickness of 0.5 mm was selected in order to avoid deformation during transport, storage and handling of the shield.

2.5 Basic testing Sacrificial Shield

Based upon a reference HBU flange dimensions, first a fully flat Sacrificial Shield was made and corrosion tested according to ASTM B117-cyclic water-salt spray tests.

The first results showed that the hot-dip zinc galvanized steel shield can provide corrosion resistance over 500 hours (Fig. 04)



Fig. 04 / Hot-dip zinc galvanized steel shield, carbon steel / shield / HBU inner ring were bolted together, salt spray test ASTM B117

- LEFT / Galvanized shield adhered to the HBU surface,
- MID / Inner surface of zinc galvanized steel shield
- RIGHT / Carbon steel surface in contact to the galvanized shield showed good protection to rust

Also corrosion brake fluid tests were performed as in the application the risk exists that brake fluid can leak on the bearing.

The shield was immersed in SHELL Super DOT 4 brake fluid for 600 hours at room temperature. No rust on the shield was observed after this test.

2.6 Extensive laboratory testing

The project team performed the extensive laboratory corrosion testing of the sacrificial shield.

Originally the testing included also mud slurry tests. However these tests were stopped as they were considered not to be harsh enough. The corrosion testing was performed according to SAE J2334 using a water-salt mixture sprayed on the test samples

The test samples

a) The clean sample has no corrosion protection means and serves as the reference



b) The Molykote sample had three beads of paste originally, two of which were between the flange and the third on the pilot



c) To test first the sacrificial working, a flat shield without rotor pilot section was made. The sample had no beads of paste anywhere on the bearing flange. The shield sits on the studs.



2.7 Corrosion test inspection procedures (Figs. 05, 06)

- All studs on these three samples are torqued to 85 ft-lb (115 Nm) according to specification.
- The test samples, HBU + corrosion protection option, were inspected every 6-days of the test cycle, simulating 6-months of vehicle life.
- Total test time 36-days, representing 36-months of service life
- Visually inspect corrosion
- Measure press-out force between hub and rotor

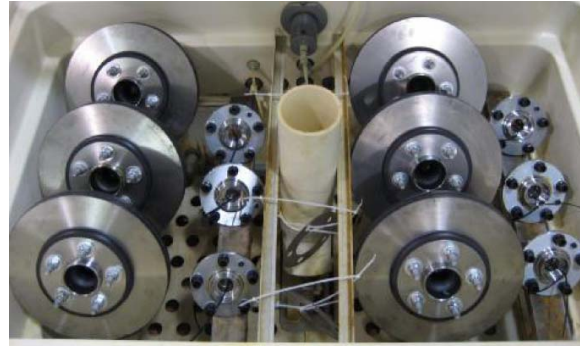


Fig. 05 / Appearance of the samples before corrosion testing
HBU test samples with rotors / one of each:
Molykote (original), Shield, and a Clean (ref) sample

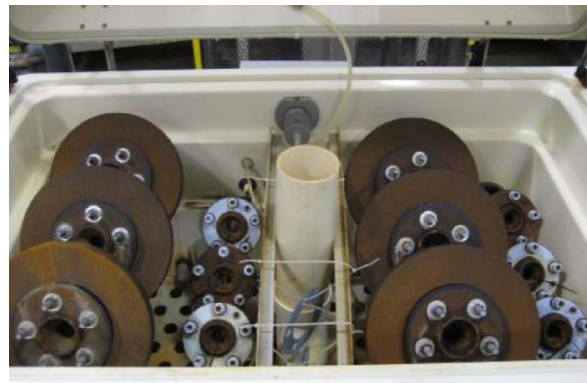


Fig. 06 / Appearance of the samples after 24-days corrosion testing

2.8 Dismounting of brake rotors from HBU flanges

The brake rotor is centred on the pilot section of the HBU flange.

If the rotor pilot on the flange and brake rotor have no corrosion protection in this section, there is a high risk that, due to "corrosion welding", the brake rotor will crack while dismounting it from the HBU flange.

This occurred with the clean sample.

As the shield sample was flat without a sacrificial pilot section, signs of corrosion welding were spotted at the end of the testing sequence.

This clearly showed that, as scheduled, the shield should be designed with a brake rotor pilot section.

The Molykote sample showed a rapid progressive increase of the dismounting force.